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A SEARCH FOR LONG-LIVED Ca^{50} AND Cr^{56}*

WILLIAM D. EHMANN and JOHN R. HUIZENGA
Department of Chemistry, University of Kentucky, Lexington, Kentucky
and Argonne National Laboratory, Lemont, Illinois

Introduction

The existence of an extinct natural radioactivity would have considerable significance in the fields of geochemistry and cosmology (Kohman, 1956). An extinct natural radionuclide would be one whose lifetime is too short for detectable amounts to be present from the time of nucleogenesis, yet long enough, to produce through radioactive decay, effects in nature that may be identified at present. A radionuclide whose half-life falls in the range from $\sim 3 \times 10^7$ to $\sim 3 \times 10^8$ years would fall into this class. At present, three known radionuclides, Pb^{205} ($\sim 3 \times 10^7$ years), Pu^{244} ($\sim 8 \times 10^7$ years), and Cm^{247} ($> 4 \times 10^7$ years) appear to have half-lives in this range. Of these, only Pb^{205} which has a stable decay product, Tl^{205}, would be important for isotopic dating. The other two radionuclides may have had, however, important thermal effects in the history of the earth.

A number of radionuclides that might be produced by two successive neutron captures on the highest mass number stable isotope of a given element are still unknown. In this work a search was made for the two nuclides Ca^{50} and Cr^{56}. Previous work by Jones (1956) has established exclusion limits for the half-life of Cr^{56} of from 2 hours to 200 years. He believed it to be long-lived. Roy and Yaffe (1957)

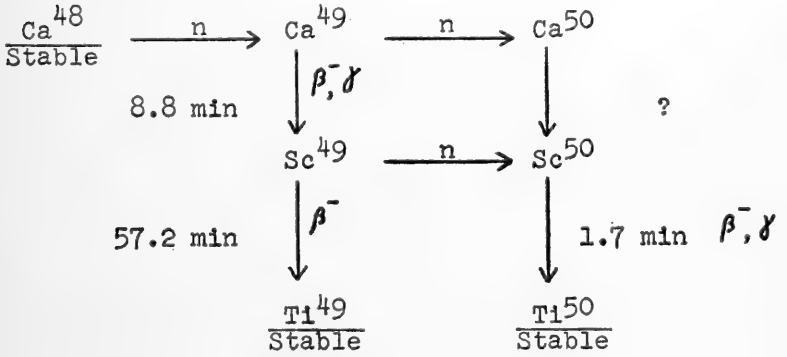

Fig. 1. Production and decay of Ca^{50}

* Based on work performed partly under the auspices of the U.S. Atomic Energy Commission.

using a long pile irradiation of enriched chromium established that:

$$t_{1/2}\ Cr^{56}/\sigma\ Cr^{55} \geqq 270 \text{ years/barn}$$

if it is not very short. No published data is available on Ca^{50}.

Both Ca^{50} and Cr^{56} were searched for in this work by use of the active daughter extraction technique. The production and parent daughter relationships for these nuclides are given in Figures 1 and 2.

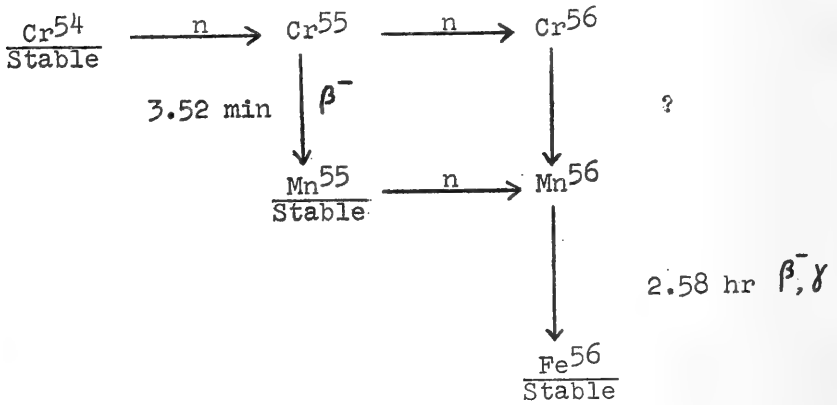

Fig. 2. Production and decay of Cr^{56}

Experimental Procedures and Results

Ca^{50}

Experimental—A 28.97 mg sample of $CaCO_3$ containing calcium enriched at Oak Ridge National Laboratory in Ca^{48} to 51.4% was irradiated in a high flux position at the Materials Testing Reactor at Idaho Falls, Idaho for approximately nine months. The total nvt received was 4.66×10^{21} neutrons-cm^{-2}. The irradiated sample was allowed to cool for one month before starting the chemistry.

The radiochemical procedures consisted of solution of the sample in dilute HCl and extration of the Sc^{50} active daughter, using Sc^{+3} carrier, into a 0.5*M* TTA solution in benzene. The efficiency of the extraction as determined with Sc^{46} tracer was $\geqq$97.5%. Since the half-life of Sc^{50} is only 1.7 minutes, rapid chemistry was required. The elapsed time from the start of the extraction to the start of the counting was always less than four minutes.

The benzene layer containing the Sc-TTA complex was quickly separated and placed in a 7 ml volume plastic vial mounted in front of a 2½″ × 2½″ NaI crystal scintillation detector. The gamma spectrum of the sample was examined for the 1.17 and 1.59 Mev gamma ray photo-peaks of Sc^{50} using a 256 channel pulse-height analyzer.

The physical geometry of the counting set-up was approximately 20%. The initial gamma spectrum obtained for a sample was compared to a "background" spectrum taken 15 minutes after the initial count in order to detect any activity in the region of the two Sc^{50} gamma ray photo-peaks.

Results—A series of five Sc extractions were made on the irradiated calcium sample in an attempt to detect the Sc^{50} active daughter of Ca^{50}. In no case were peaks observed at 1.17 or 1.59 Mev and no difference outside of the statistical standard deviation was observed between the first count and the final count on a given extraction. The background counting rate in the vicinity of the 1.17 Mev photo-peak was $\sim$ 8 counts/minute/channel and in the vicinity of the 1.59 Mev photo-peak was $\sim$ 1 count/minute/channel.

Assuming a counting rate for Sc^{50} less than or equal to the standard deviation of the initial counting rate in the area bracketing the 1.59 Mev peak, the following ratio is obtained:

$$t_{1/2}\ Ca^{50}/\sigma\ Ca^{49} \geqq 1 \times 10^2 \text{ years/barn}$$

If the cross section of Ca^{49} is estimated to be approximately 0.1b, a lower limit to the half-life of Ca^{50} of approximately 1×10^3 years is obtained. The possibility that Ca^{50} might be very short lived is, of course, not excluded.

Cr^{56}

Experimental—A 36.695 mg sample of Cr_2O_3 containing chromium enriched at Oak Ridge National Laboratory in Cr^{54} to 83.1% was irradiated in a high flux position at the MTR reactor for approximately nine months. The total nvt was also 4.66×10^{21} neutrons-cm^{-2}. The sample was allowed to cool for 2 months before the start of the chemistry.

The radiochemical procedures consisted of fusion of the sample in Na_2O_2 followed by solution in dilute HCl. The acid solution was treated with a few drops of H_2O_2 and evaporated to near dryness. The residue was then made up to 15 ml with H_2O and scavenged with CuS.

$Cr(OH)_3$ was separated by precipitation with NH_4OH and dissolved in 15 ml of concentrated HNO_3. Mn^{+2} carrier was added and solid $KClO_3$ added slowly with heating to affect oxidation of Mn^{+2} to MnO_2 and Cr^{+3} to $Cr_2O_7^{-2}$. The MnO_2 was filtered off and discarded. This MnO_2 precipitation step was repeated several times using Ir carrier to remove Ir^{192} contamination, which follows this Mn chemistry. The $Cr_2O_7^{-2}$ was reduced to Cr^{+3} between MnO_2 precipitations by addition of concentrated HCl and a few drops of H_2O_2

followed by heating. Zr^{95} contamination was removed by scavenging with $BaZrF_6$.

The purified Cr sample at this point showed only Cr^{51} activity in a gross gamma ray pulse-height analysis. This sample was then used to attempt the extraction of the Mn^{56} active daughter of Cr^{56}. The method used was addition of a known amount of Mn^{+2} carrier to the purified Cr^{+3} solution followed by oxidation to MnO_2, as before. This MnO_2 which carried any Mn^{56} present was reprecipitated several times as above with inactive chromium carrier to remove traces of Cr^{51}. Solution of the MnO_2 between precipitations was affected by use of concentrated HNO_3 and a few drops of H_2O_2. The final MnO_2 precipitate was filtered on a weighed paper disk, weighed to determine chemical yield, and mounted on a card for beta counting of the 2.58 hour half-life Mn^{56}. The time required for the chemistry was about two hours.

Counting was done on the first shelf of a standard end-window proportional counter having a background of 10.8 c/m. A 35.5 mg/cm^2 Al absorber was used to eliminate a high background of unidentified low energy betas.

Results—A series of four MnO_2 samples were prepared as above. The samples were counted at short intervals for approximately six hours. In no case was any decrease in the counting rate observed corresponding to the 2.58 hour decay of Mn^{56}. In the best run the background corrected counting rate of the MnO_2 sample through the absorber was 35 c/m. No variation in this counting rate outside of the statistical standard deviation was observed over a period of more than five hours.

If the counting rate of Mn^{56} at the time of the initial count is taken to be less than or equal to the standard deviation of the counting rate for the initial ten minute count, the following ratio is obtained:

$$t_{1/2}\ Cr^{56}/\sigma\ Cr^{55} \geqq 1100 \text{ years/barn}$$

If the σ Cr^{55} is estimated to be approximately 10 barns, then the lower limit for $t_{1/2}$ Cr^{56} is approximately 1.1×10^4 years, if it is not very short lived. Since Jones (1956) has found that the half-life of Cr^{56} is not in the range of 2 hours to 200 years, the exclusion limits for the half-life of Cr^{56} may now be extended to from 2 hours to approximately 1.1×10^4 years.

The possibility that Ca^{50} and Cr^{56} might have half-lives in the range specified for extinct natural radionuclides is, therefore, not excluded by this work. In order to finally extend the exclusion limits through this half-life range, much longer irradiation times and larger, highly enriched samples will have to be used.

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MATERIALS, TECHNIQUES AND METHODS IN TEACHING PSYCHOLOGY IN 34 SECONDARY SCHOOLS

PAUL McNEELY
Asbury College, Wilmore, Kentucky

Introduction

After a brief introduction, this article will present the reactions of students and teachers to practices in current use in psychology classes in Indiana secondary schools. The procedure and major findings of the author's doctoral thesis relative to materials, techniques and methods will be given with some implications that they may have for Kentucky high schools.

According to T. L. Engle[1] Kentucky and Arkansas are the only two states in which 25 percent of the secondary schools offer a course in psychology. A letter from the Department of Education of Kentucky[2] states that of the 420 public high schools, 101 offer a course labeled Social Psychology. Of the 68 non-public schools, 6 offer a course with the above title.

Dr. Halice Wiggs[3] found in his doctoral study that 82.7 percent of the principals of Indiana are in favor of the course. Actually 14 percent of the schools of this state offer the course. Nationally, from the article by Engle referred to above it was learned that over 1,082 high schools offer the course. This is 8.4 percent of the total of 12,939 high schools reported by officials in 34 states.

The American Psychological Association has a special committee working on the problem at the secondary level. Since one fourth of the high schools of Kentucky offer a psychology course it would seem of interest and value to present the major findings of the Indiana study conducted in 34 high schools. It is hoped that some of the findings will be helpful to those in Kentucky who are concerned with teaching or curriculum construction.

The writer's study[4] was conducted during the spring of 1956. A stratified sampling of 34 Indiana high schools in a 30 mile strip north and south and east and west was made. Personal visits were made to schools and tests given to 1,236 students (715 females and 521 males) who were enrolled in psychology courses. The 38 teachers in the 34 schools visited were mailed questionnaires before visitation. These were collected at visitation and later analyzed. One teacher did not return his questionnaire making a 97.4 percent return.

Major Findings of the Thesis

By confining our discussion to the data presented in this thesis, it is possible to summarize as follows:

Major findings related to problems of students. Most students of high school psychology thought the course had been helpful, but they did not feel free to discuss their personal problems with their teacher. One reason for this could have been that most psychology teachers had only five hours or less of free time per week for personal counseling. Teachers tended to overestimate the degree of help students received on their problems. Students checked *Reader's Digest, Life,* and *Colliers* as the magazines most valuable in solving their personal problems. The outstanding problem on which the students desired help but did not obtain it was choosing a career. Not only were more females enrolled in the psychology course, but they also apparently received more help from the course.

Major findings related to topics. The topic liked least by students was how to study. The largest percentage of students indicated that the topics misconceptions about psychology, and how to study, should be used less than at present. On the other hand, students desired more use of such topics as courtship and marriage, prevention of mental disease, and emotions and their control. The favorite topic of students was personality. A higher percentage of students indicated that this topic had helped them more than any other topic. Topics of highest interest were distributed throughout the course.

Major findings related to materials. The text most frequently used was by Engle, *Psychology: Its Principles and Applications,* second edition, in a course which was almost always labeled Psychology. Teachers rarely used a syllabus, but almost half of them used supplemental reading in addition to the text. The least frequently used materials were recorders, slides, World Book, television, health charts, and mimeographed outlines while the most frequently used materials were filmstrips, reference books, study questions, newspapers, and magazines. Students desired more use of films and filmstrips, and less use of World Book, health charts, and mimeographed outlines.

Major findings related to methods. The most unpopular method according to students was the writing of an autobiography. Dramatization and skits were not very popular. Both teachers and students agreed that by far the most frequently and best used methods were lecture and discussion. When outside speakers were used, they were more frequently a psychologist or a social worker. Some teachers did not use any speakers but one used as many as 10 different persons.

Both teachers and students agreed that more outside speakers should be used in the course.

Experiments performed as demonstrations and those performed by individual students were power of observation, reaction time, learning time, mental telepathy, and conditioned response.

The tests most frequently explained to students by teachers were Rorschach, Kuder Preference Record, Draw a Picture Test, and California Test of Mental Maturity. Tests most frequently administered to students were Kuder Preference Record and California Test of Mental Maturity.

Major findings related to the evaluation of the course. Most teachers gave a combination of objective and essay tests. An opportunity was given for discussion of examinations. Both teachers and students preferred announced written quizzes and chapter tests. Teachers gave these types of examinations. Unannounced quizzes were not popular with either teachers or students. Teachers thought the psychology course was average in difficulty; students tended to think it was easy.

Major findings related to the high school psychology teacher. Psychology teachers tended to be enthusiastic about their work. They desired summer workshops, magazine articles, seminars, and other aids that would help them in presenting psychology at the secondary level. Those teachers who used a variety of teaching methods seemed to have better rapport with their students as judged by their students' willingness to discuss personal problems with their teacher. The size of the school, class, number of years psychology had been taught did not seem to be as important as the relationship that existed between the student and the teacher. Even the type of materials and methods used seemed to be secondary to the personality of the teacher. Very few psychology teachers were rated below average in their ability to present materials and methods in high school psychology.

Implications

If it can be inferred that Indiana and Kentucky present analagous situations as far as psychology at the secondary level is concerned, then it would seem that more attention should be given to the preparation of high school psychology teachers. This seems to indicate that more free time should be given for personal counseling, more use of outside speakers, and an increased volume of psychological information that is scientific yet adapted to the use of high school psychology teachers.

Summary

Results from a survey of the teaching of psychology in 34 high schools are presented, together with some of the possible practical applications of the findings for Kentucky high schools offering a course in psychology.

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3. Wiggs, H., *The Status of Psychology in Indiana Secondary Schools.* Indiana University, Bloomington, 1952.
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A STUDY OF THE WORM SNAKE, *CARPHOPHIS AMOENUS* SAY, IN KENTUCKY

ROGER W. BARBOUR
Department of Zoology, University of Kentucky, Lexington, Ky.

The worm snake, *Carphophis amoenus* Say, ranges from southern New England south to central Georgia and Alabama and west to eastern Nebraska, Kansas, Oklahoma, and Texas. In the Mississippi valley, it extends southward to the Gulf. Three subspecies are currently recognized, *C. a. amoenus, C. a. helenae,* and *C. a. vermis.* The latter is essentially confined to the area west of the Mississippi river, while the preceding two are found east of the Mississippi. *Carphophis a. helenae* ranges from the Mississippi eastward to the Appalachians; *C. a. amoenus* ranges in the Appalachians and eastward to the coast. (Conant, 1958). The three subspecies may be separated by the following key:

A. Pink of belly extending up sides onto third scale row; color above usually purplish black ..... *C. a. vermis* (Western Worm Snake)

AA. Pink of belly extending up sides onto only first or second scale row; color above usually plain brown.

B. Internasals and prefrontals distinct ..... *C. a. amoenus* (Eastern Worm Snake)

BB. Each prefrontal fused to the corresponding internasal ..... *C. a. helenae* (Midwest Worm Snake)

The species ranges throughout the state of Kentucky. Schmidt (1953) stated that *C. a. amoenus* occurs ". . . east of the Appalachians," which implies that only one subspecies, *Carphophis a. helenae* Kennicott, occurs in Kentucky.

The 116 specimens of *Carphophis amoenus* from Kentucky in the zoological collections of the University of Kentucky have been examined. Measurements, scale counts, condition of head plates, overall dorsal coloration, sex, number and size of eggs, if present, date and locality collected, and habitat, where known, were recorded for each specimen. These data are summarized in this paper.

The specimens were largely collected by the author during the past eight years. The Research Fund Committee of the University of Kentucky provided financial assistance incident to the collection of many of the specimens.

Distribution in Kentucky

Previous literature records, substantiated by specimens I have examined, leave no doubt that both *C. a. amoenus* and *C. a. helenae,* as currently understood, occur in Kentucky. Fig. 1.

Fig. 1. The distribution of *Carphophis amoenus* in Kentucky. Hexagons represent records of *C. a. helenae;* circles, *C. a. amoenus;* triangles, intergrades. Solid symbols represent specimens examined; hollow symbols, litrature records.

Carphophis amoenus amoenus Say. Literature records are: "throughout Kentucky"—(Garman, 1894); Breathitt county (Dury and Williams, 1933); Bell, Harlan, and Letcher counties (Barbour, 1950b); Harlan and Letcher counties (Barbour, 1950a); Breathitt county (Bush, 1959).

I examined 44 worm snakes that are referred to *C. A. amoenus.* They were collected from the following counties: Bell, 1; Breathitt, 21; Harlan, 21; and Lee, 1. Thirty-four of the specimens have the internasals and prefrontals separate, 6 have them fused, and 4 are intermediate in this characteristic.

Carphophis amoenus helenae Kennicott. Literature records are: "throughout Kentucky"—(Garman, op. cit.); Anderson and Fayette counties—(Funkhouser, 1925); Edmonson, Hardin, and Jefferson counties—(Burt, 1933); Edmonson county—(Bailey, 1933); Carter county (Dury and Williams, op. cit.); Edmonson county (Hibbard, 1936); Fulton county (Parker, 1939); Rowan county (Welter and Carr, 1939); Oldham, Larue, and Warren counties (Barbour, 1950b).

Thirty-four of the specimens examined are referable to *C. a. helenae.* They were taken from the following counties: Anderson, 1; Clark, 1; Edmonson, 6; Garrard, 4; Green, 2; Jessamine, 9; Menifee, 2; Nelson, 3; Russell, 1; Todd, 4; and Warren, 1. Twenty-six of the specimens have the internasals and prefrontals fused; five have them separate, and four are intermediate.

Although here considered *C. a. helenae,* the four specimens from Todd County (the westernmost specimens examined) are unlike any other *Carphophis* examined in the degree of contrast between the back and belly color, strongly resembling *C. a. vermis.* They differ from *vermis,* however, in the fact that the belly color extends only onto the second scale row. The specimens from Edmonson County show this marked contrast between back and belly color to a lesser degree. Additional collecting in western Kentucky will possibly reveal the *Carphophis* population there to be intermediate between *C. a. helenae* and *C. a. vermis.*

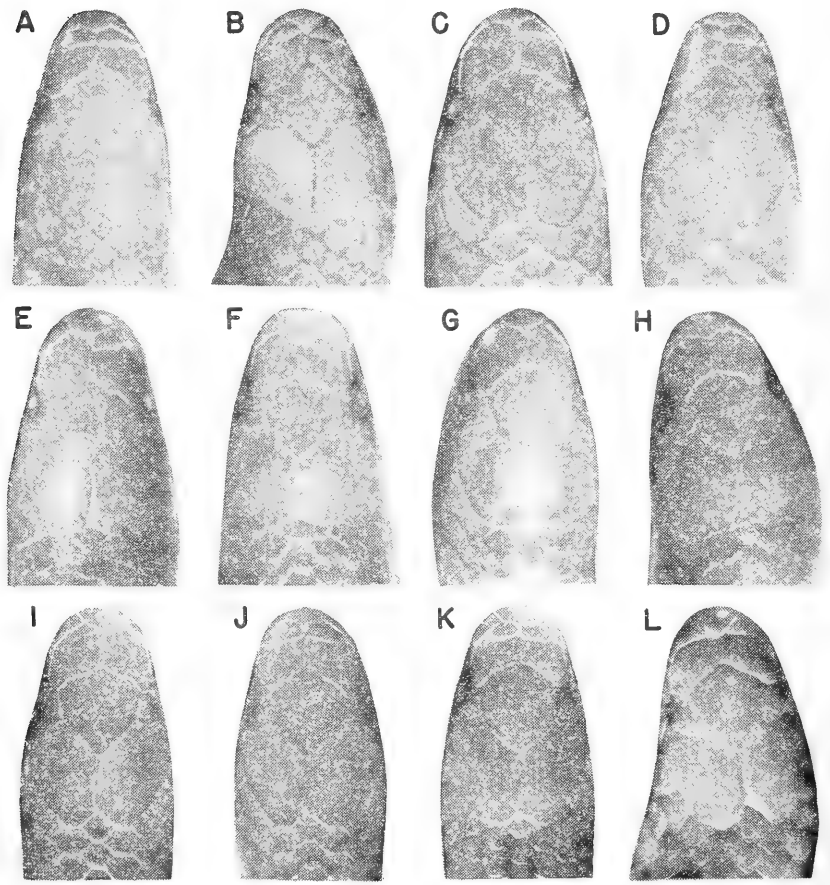

Fig. 2. Photographs of a series of heads of *Carphophis amoenus* from Kentucky. A typical *C. a. amoenus; B-H,* intergrades between *C. a. amoenus* and *C. a. helenae;* I, typical *C. a. helenae;* J, individual with partly fused internasals; K, individual with partly fused prefrontals; L, individual with internasals and prefrontals fused into a single large plate.

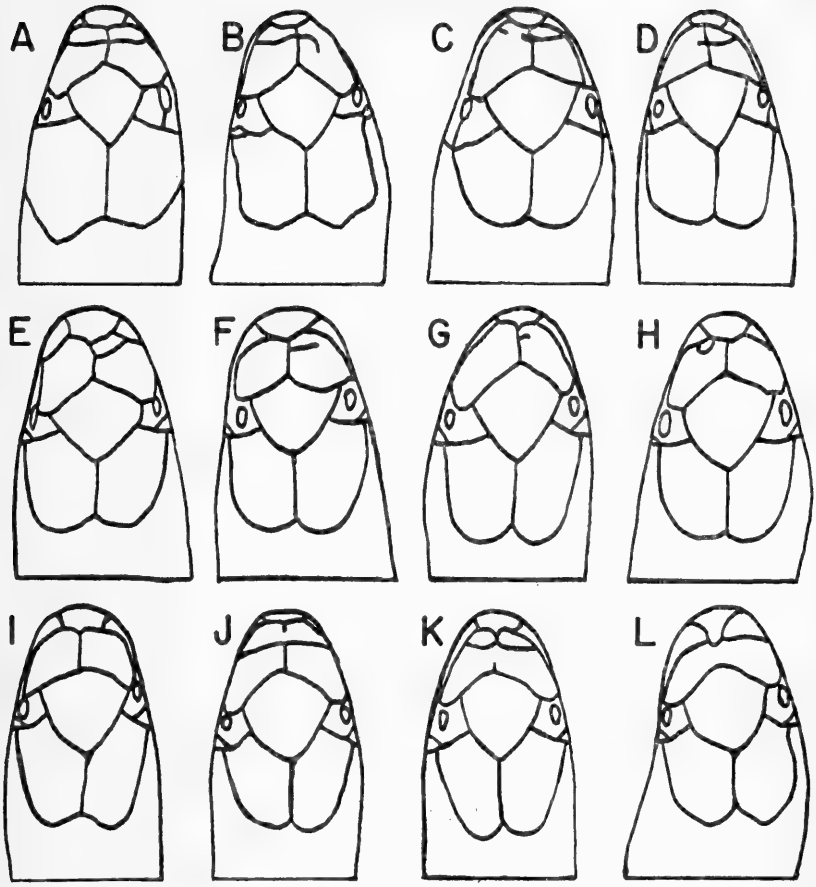

Fig. 3. Tracings from the photographs shown in Fig. 2.

Carphophis amoenus amoenus Say X *Carphophis amoenus helenae* Kennicott. Barbour (1950b) has pointed out that "along the western edge of the mountains a tendency toward intergradation appears." Dury and Williams (1933) mentioned a specimen, under the name *helenae,* from near Barbourville, Knox county, that has "the internasals and prefrontals fused on the left and separate on the right."

Thirty-eight specimens have been examined that are considered intergrades. They were collected from the following counties: Bath, 6; Carter, 9; Fleming, 10; McCreary, 9; Rowan, 1; and Whitley, 3. Fourteen of these have the internasals and prefrontals separate; 19 have them fused; and 5 are intermediate.

Apparently a change is occurring in the *Carphophis* population of Rowan and adjacent counties. Welter and Carr (1939) stated "among

all *Carphophis* examined in eastern Kentucky no typical *amoena* were found." Barbour (1950b) pointed out the presence of typical *amoena* and intergrades in the area. In this study, 26 specimens from the adjoining counties of Carter, Rowan, Bath, and Fleming, collected since the appearance of the paper of Welter and Carr, were examined. Sixteen of them exhibit fused internasals and prefrontals; in 7 they are separate, and 3 are intermediate. These data indicate that these counties are in the range of intergradation between the two subspecies.

Intergrades between the two subspecies are quite variable, representing practically all possible stages in the degree of fusion of the internasals and prefrontals. Occasional specimens are found with fused internasals or prefrontals. In one case, the internasals and prefrontals were fused into one large plate. Some of these degrees of fusion are shown in Figs. 2 and 3.

Habitat

Worm snakes in Kentucky are almost invariably found beneath some object, generally a rock or a log. They may be found in a great variety of habitats, ranging from virgin timber through brushy areas to weed-grown fields, and even open pastures. They are, however, rarely found far from a wooded area.

Food

Of the 116 specimens examined, only 22 contained food. In every case, only earthworms, along with the detritus from the alimentary canal of the worms were found. Barbour (1950a) reported only earthworms from the stomachs of 10 of 22 individuals collected in Harlan county, Kentucky.

Reproduction

A total of 20 egg-bearing females was examined, all taken between February 4 and June 18. Average egg number per female was 2.6, varying from 2 to 5. Average egg length in February (4 eggs) and March (2 eggs), was 5mm.; in April (19 eggs), 7.3mm.; in May (18 eggs), 15mm.; and in June (10 eggs), 18.6mm. Blanchard (1925) reported that 5 captive individuals laid eggs between July 4 and 11. Bush (1959) reported that in Breathitt county, Kentucky, "Egg laying seemed to take place about mid-June. Seven females having depositional-sized eggs had an average clutch of 3.2; the average egg length was 24.2mm. Ten females taken between June 19 and July 2 had no eggs." Funkhouser (1945) stated that *Carphophis amoenus* "lays eggs in late summer." Data herein presented indicates that in Kentucky, egg-laying occurs about the middle of June. All females of egg-laying size (herein indicated to be a minimum of about 185mm. in total

length) taken prior to June 10 contained enlarged eggs. No adult female taken after June 18 contained enlarged eggs. Thirty-three adult females averaged 233.4mm. in total length, ranging from 185 to 282mm. The average of those with eggs (20 specimens) was 233.4; those without eggs (13 specimens) averaged the same. Table 1.

Table 1.—Number and Size of Eggs in *Carphophis amoenus* from Kentucky (Measurements are in mm.)

Date	Number of females	Females with eggs	Length of egg-bearers	Length of non-egg-bearers	Number of eggs	Length of eggs (mean and extremes)
Feb. 4	2	2	248,248	.....	2,2	5 (5-5)
March 14	1	1	232	.....	2	5
April 8	2	2	185,222	.....	2,3	8.5 (7-10)
April 18	2	2	215,227	.....	2,5	2.5 (2-3)
April 23	1	1	226	.....	2	13
April 24	1	1	246	.....	2	13
April 28	2	2	212,215	.....	1,2	9 (8-10)
May 3	1	1	218	.....	3	12
May 9	3	3	228,236,255	.....	2,2,3	16.6 (14-19)
May 10	2	2	241,246	.....	3,4	15.5 (14-17)
June 10	1	1	249	.....	3	13
June 13	1	0	.....	282	.....	.....
June 18	3	2	237,260	270	3,4	21 (20-22)
June 20	1	0	.....	200	.....	.....
June 25	1	0	.....	283	.....	.....
June 28	4	0	.....	206,212,230,256	.....	.....
July 2	2	0	.....	200,206	.....	.....
Aug. 5	1	0	.....	187	.....	.....
Aug. 18	1	0	.....	255	.....	.....
Aug. 24	1	0	.....	247	.....	.....

Sexual Dimorphism

Measurement of the total length and tail length of 48 females and 65 males revealed that the males have a proportionally longer tail than the females. Relative tail length (tail length ÷ total length) was calculated for the specimens. There was no appreciable change with increase in total length. In the females, the tail averaged 14.4 percent of the total length, with extremes of 12.9 to 16.1 percent. In males, the percentage ranged from 16.4 to 20.5, averaging 19.1. This difference is sufficiently great to be readily discernible to the experienced eye.

Summary

One hundred sixteen specimens of *Carphophis amoenus* from Kentucky were examined. Food consisted entirely of earthworms. Egg-laying occurred in the middle of June, and the average number of eggs was 2.6, varying from 2 to 5. Measurements of the tail and total

length of 48 females and 65 males revealed that the tail of the females averaged 14.4 percent of the total length, whereas that of the male averaged 19.1 percent. The worm snake of the southeastern mountains of Kentucky is *C. a. amoenus;* that of central and western Kentucky is *C. a. helenae.* Intergradation between the two subspecies occurs along the western border of the mountains of eastern Kentucky. There is some evidence that worm snake of western Kentucky is intermediate between *C. a. helenae* and *C. a. vermis.*

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THE CHROMOSOME NUMBER OF *HELIANTHUS DECAPETALUS*[1]

DALE M. SMITH
Department of Botany, University of Kentucky, Lexington

In an earlier paper (Heiser & Smith, 1955) on chromosome numbers in Helianthus, it was reported that *H. decapetalus* L., was an apparent tetraploid with a chromosome number of N=34. This report was based upon material collected in the vicinity of Bloomington, Monroe Co., Indiana. Subsequently, new cultures of *H. decapetalus* were obtained from other localities which proved to be diploid (N=17).

Methods and Materials

Plants from which chromosome counts were obtained grew in experimental areas at Indiana University and the University of Kentucky, as well as natural habitats. Counts were obtained from microspore mother cells in each case, and in a few plants additional determinations were made using root-tips. Buds for meiotic studies were obtained at the proper age and fixed in 95% ethyl alcohol and glacial acetic acid (3:1) for approximately 24 hours and then transferred to 70% ethyl alcohol for storage. Most observations were made using temporary aceto-carmine squashes, but a few slides were made permanent for future reference and record. Root-tip material was obtained from potted plants in the green house. A pre-treatment was found to be necessary to study adequately the mitotic chromosomes. Best results were obtained using 0.1% aqueous colchicine for four hours at approximately 4°C., or a mixture of 0.1% colchine and 0.02M 8-quinolinol (1:1) also for four hours at 4°C. The former treatment was somewhat better for mere counting, but the latter was superior for studies of chromosome morphology. Staining was by the Feulgen technique and aceto-carmine. Voucher herbarium specimens are on deposit at Indiana University and the University of Kentucky. The chromosome counts obtained are listed in Table 1.

Conclusions

The widespread occurrence of both diploid and tetraploid populations of *H. decapetalus* is clearly indicated by the results presented in Table 1. Comparable situations have been reported in a number of other plant genera, but this is the first instance of this type in the genus Helianthus. It is rather unusual that similar situations have not

[1] Supported in part by NSF grant G-6380.

Table 1.— Chromosome Numbers of *Helianthus decapetalus* L.

State and County	N-chromosome number	Collector and number	
Maine			
Somerset County	17	Smith	C-5
Vermont			
Bennington County	17[2]	Eaton	565
New York			
Chautauqua County	34	Heiser	P-190
Pennsylvania			
Crawford County	34	Heiser	4558
Virginia			
Rockingham County	17	Smith	P-412
Smyth County	17	Martin	s.n.
West Virginia			
Randolph County	17	Smith	P-406
Indiana			
Brown County	34	Heiser	P-299
Lawrence County	34	Smith	1050
Monroe County	34[2]	Heiser	3005
Monroe County	34[2]	Heiser	3017
Monroe County	34	Smith	P-272
Monroe County	34	Smith	1071
Kentucky			
Breathitt County	34	Smith	K-115
Martin County	17	Smith	C-1
Wolfe County	34	Smith	K-122

been discovered in other species of Helianthus in light of the high degree of polyploidy which has been previously reported (Heiser & Smith, 1955). The closest approach is seen in the complex presently treated as *H. strumosus* L., in which both tetraploids (N=34) and hexaploids (N=51) are known.

As yet, I have not been able to separate the two cytodemes of *H. decapetalus* morphologically. If differences exist, they seem to be largely quantitative, with the tetraploids being somewhat more robust than the diploids. Studies are also in progress dealing with the problem of autopolyploidy *vs.* allopolyploidy in this and related species of Helianthus. The available evidence strongly suggests that tetraploid *H. decapetalus* may be a true autopolyploid, but the final determination must be based upon more data than is presently available.

Summary

A perennial sunflower, *Helianthus decapetalus* L., originally reported to be a tetraploid (N=34), is shown to include diploids

[2] I am indebted to Dr. C. B. Heiser, Jr., of Indiana University, for these counts.

(N=17) as well. Tetraploids are reported from ten localities, while diploids are now known from six stations. The two cytological types are closely similar morphologically, and it seems possible that this may be a case of true autopolyploidy.

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SUGARS IN THE NECTAR OF THE POINSETTIA, *EUPHORBIA PULCHERRIMA**

SISTER VIRGINIA HEINES and SISTER MARY ADELINE O'LEARY
Nazareth College, Louisville, Kentucky

Very few determinations on the individual sugars in flower nectars have been carried out. The older analytical methods required large volumes, which were not available in the nectars investigated. By using the technique of paper chromatography, it is now possible to determine the sugars present in micro-amounts of material. Previous work done on nectars by Wykes (1) has shown that sucrose, glucose and fructose are not equally attractive to bees. He analyzed (2) the nectars from twelve species of flowers by paper chromatography and found that the proportions of glucose and fructose varied greatly in different species. The present study investigates the total sugar content of the fresh nectar of the Poinsettia, and the separation of the individual sugars by paper chromatography.

Experimentation

Total Sugars by the Anthrone Method (3)

Four hundredths of a milliliter of the clear, viscous nectar were drawn from the yellow gland of the cyanthium and diluted with distilled water to 2 ml. Three milliliters of the anthrone reagent were pipetted into each of three test tubes, followed by 0.2 ml. of a standard glucose solution (0.02 mg./ml.) into the first tube, 0.2 ml. of distilled water into the second tube as a blank, and 0.2 ml. of the diluted nectar into the third tube. The solutions were mixed by tapping and tubes placed in a thermostatically controlled water bath at 80°C for 10 minutes, then cooled under tap. By using Beckman B and Coleman (6C) spectrophotometers the optical density was read at 640 mμ.

Individual Sugars

1. Circular Chromatograms. The circles of Whatman No. 1 paper (32 cm.) were spotted with known sugars and nectar solutions, placed in desiccators with strings for wicks, and let run for 18 hours in n-butanol-pyridine-water, 6:4:3, solvent. They were removed, air-dried, and dipped into an aniline phthalate reagent. After drying for several hours at room temperature the chromatograms were heated for 5 minutes at 105°C and then 10 minutes longer at 120°C to bring out the sucrose (4). Examination under ultraviolet light helped to identify the sugars.

* Supported in part by grant from National Institutes of Health.

2. Sheet Chromatograms. Sheets of Whatman No. 1 paper, 23 × 23 cm., were spotted with known sugars and nectar samples using 0.01 ml. volumes. After 24 hours in the solvent, the silver nitrate method was used to determine the sugars (5). Quantitative analysis of the nectar was made by the Pridham method (6). Standard solutions of pure glucose and fructose were spotted in 0.01 ml. volumes so as to extend over a range of 50γ to 175γ by weight. The chromatograms were developed with the 6:4:3 solvent for 24 hours, air-dried, dipped into the p-anisidine hydrochloride reagent, and heated at 130°C. for 10 minutes. The colored spots and blanks were cut from the paper and eluted by shaking 5 minutes with 3 ml. of the methanolstannic reagent. Optical density values read at 640mμ were plotted against the weight of standard glucose and fructose solutions. The standard curves were used to determine the amount of glucose and fructose in the nectar sample.

Several drops of the viscous nectar were expelled from the yellow gland onto a watch glass and kept in an airtight box in a warm room for a period of six months. The sugars crylstallized out and became embedded in a clear solid. Chromatograms were run on these crystals and the ratio of glucose to fructose calculated.

Results and Discussion

The total sugar content of the nectar determined by the anthrone method was found to be 50% calculated as glucose:

$$\frac{0.26 \text{ O.D. (nectar)}}{0.56 \text{ O.D. (Std. glucose)}} \times 0.02 \text{ mg.(Std.)} \times \frac{10}{0.2} = 5 \text{ mg./10 ml.}$$

The original sample (0.04 ml.) was diluted to 2 ml.; 0.5 ml. of this was made up to 10 ml. and 0.2 ml. of this last dilution was used to determine the total sugar content.

Circular chromatograms made on samples of the fresh nectar showed presence of glucose, fructose and sucrose. The crystalline product indicated glucose and fructose only. Zimmerman (7) found small amounts of the enzyme, invertase, in the nectar of the Poinsettia, *Euphorbia pulcherrima,* which could account for the absence of sucrose in the crystalline sample. Calculated values of these from the standard curves gave 46γ of glucose and 35γ of fructose, out of a spotting of 82γ sample. The crystals were of the orthorhombie type (8). These results are summarized in Table 1. The ratio of glucose to fructose (G/F) was found to be 1.39, which corresponds closely to that of one species of another plant investigated by Wykes.

Table 1.— Sugars in Crystallized Nectar of the Poinsettia

Sugars		Volume applied to Chromatogram	Optical Density	Weight sugar found γ	
Glucose	(1)	10 μl	0.210	47	
	(2)	10 μl	0.200	45	
	Average				46
Fructose	(1)	10 μl	0.090	34	
	(2)	10 μl	0.095	36	
	Average				35
	Total sugars in crystalline nectar				81
	Total sugar calculated from sample weight				82

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SULFUR COMPOUNDS AS INHIBITORS IN OIL BEARING CORROSION

N. W. HALL,[1] W. D. WILLIAMS,[2] and J. R. MEADOW
Department of Chemistry, University of Kentucky, Lexington, Ky.

Reactions in an internal combustion engine are varied, complex and uncertain. Lubricating oil temperatures may range from 120°C to 250°C. Oil is whipped around as a mist in the crankcase and absorbs considerable quantities of air. Under these conditions, lubricating oil is subject to increased oxidation and breakdown. The breakdown processes are necessarily very complex. The order of events and the intermediate reaction products depend on such factors as structure of oil molecules, temperature, pressure, presence of air, inhibitors, metallic catalysts, and others. Such a combination of factors introduces a considerable element of uncertainty into any speculation about the nature of breakdown products (1).

The formation of lacquers and sludges as well as the corrosion of bearings is usually attributed in part at least to the attack of the oil by oxygen (2). Metals are not usually corroded by the hydrocarbon components per se which make up a very large portion of any lubricating oil, but corrosion does occur under certain conditions as the result of the presence of impurities or "catalysts" in lubricants and as a result of the development of oil oxidation products. Lubricants can vary as much as a hundredfold in their bearing corrosion tendencies. Bearings themselves differ greatly as to their resistance to corrosion in oils. Copper-lead and cadium-base bearings have greater mechanical strength than babbit bearings, but unfortunately they are more subject to chemical attack at elevated temperatures by oxidation products of the oil. Thus much work has been devoted to the problem of finding so-called additives which will suppress the oxidation of the oil and thereby decrease the harmful effects on the engine and bearings as well as increase the life of the oil.

The literature on the breakdown of lubricants reveals many different viewpoints regarding the mechanism of oil oxidation and the role of antioxidants or inhibitors present in an oil (3). Numerous investigators have studied the effects of various types of compounds on the stability of oils when they are subjected to oxidative conditions (2-15). In most instances the extent of oil oxidation, with or without inhibitors, has been reported in terms of oxygen absorbed, acidity developed, the amount of sludge formed in the oil after a given time, and to some extent the corrosion of a metal surface.

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[1] Present address, Shell Oil Company, Houston, Texas.
[2] Present address, Harding College, Searcy, Arkansas.

The only completely satisfactory test on a lubricant is necessarily long, tedious and expensive. Such a test would be a long engine test, and this would be followed by a thorough road test and examination of engine parts thereafter. Obviously, many shorter screening tests have been devised to help arrive at some conclusions about the stability of oils and what inhibitors should be used in them.

It is known that lubricating oils contain many naturally occurring sulfur compounds which may function as oxidation inhibitors (6). Depending on the source of the oil, the amount of sulfur compounds present may vary from a trace to as much as twenty percent (6). Since lubricating oils are so complex, it is impossible to determine the exact structure of the sulfur compounds present. As suggested by Denison and Condit (7) it is perhaps better to study the problem of sulfur inhibition of oils by the use of known sulfur additives and noting their effect on the oxidation of a base stock oil of known sulfur content. These authors studied the inhibiting effects of several kinds of sulfur compounds on the oxidation of completely desulfurized oils. They concluded that thioethers, having at least on aliphatic or cycloaliphatic group, were the most effective inhibitors tried. Their findings were based on oxidation rates using a Dornte type of apparatus (8) for measuring the volume of oxygen absorbed by a given sample of oil.

The purpose of our investigation was to study organic sulfur compounds as corrosion inhibitors, or possibly corrosion catalysts, and note the actual effects produced on a bearing strip. The choice of bearing strip was that of a cadmium silver metal surface.[3] The test used was similar to the one described by Moran, Evers and Fuller (17) which is an air blowing test for indicating the corrosive effect of oils on cadmium silver bearing surfaces. This type of short test is used in some laboratories as a preliminary screening test for studying oil additives. Because of the very complex nature of metal corrosion which takes place during the oxidation of a lubricating oil at elevated temperatures, especially in the presence of organic sulfur compounds, one should recognize that totally different results might be expected when the same compounds are used with other bearing metal surfaces, or when experimental conditions are appreciably changed.

Materials Employed

Many of the sulfur compounds listed in Table II were obtained directly from vendors in a high degree of purity. This would include

[3] Private communication, E. W. Fuller, Socony-Mobil Oil Co., Paulsboro, New Jersey.

such compounds as those numbered 1 to 8 incl., 10 to 15 incl., 22 and 32 in Table II. No. 6, however, contained a mixture of isomers.

The sulfides numbered from 23 to 29 incl. were synthesized from alcoholic sodium sulfide and the necessary alkyl bromide in each case. No. 30 and No. 31 were prepared from ethylene oxide and the corresponding mercaptan. All of the disulfides listed in Table II, with the exception of compound No. 39, were made according to the method of Noller and Gordon (18) in which the alkyl bromide was allowed to react with an alcoholic solution of sodium disulfide. Tert-dodecyl disulfide (No. 39), however, was prepared from the sodium salt of tert-dodecyl mercaptan and iodine dissolved in CCl_4. The sulfones, No. 16 to 21 incl., were prepared directly from the sulfides by oxidation with acid permanganate solution. The three sulfide polymers in the miscellaneous group (Nos. 43, 45 and 46) were prepared from the necessary polymethylene dibromide in each case and alcoholic sodium sulfide solution. Ethylene disulfide polymer (No. 44) resulted from the reaction between ethylene bromide and sodium disulfide solution. 1,4-Dithiane (No. 47) was obtained as a by-product in the preparation of ethylene sulfide polymer (No. 42) from ethylene bromide and sodium sulfide. Methyl-n-amyl-1,3-dithiane (No. 48) was the condensation product from 1,3-propanedithiol and methyl-n-amyl ketone in the presence of dry hydrogen chloride.

The blank oil used as a base in all of the corrosion tests was a solvent refined, S.A.E. 20 grade, paraffinic type of oil generously furnished for our purpose by the Socony-Mobil Oil Company. Some of the physical characteristics and analytical properties of this oil are listed below.

Table 1.— Properties of Base Oil

Gravity, °A.P.I.	31.0	Viscosity Index	110
Specific Gravity, 60°F.	0.8708	Sulfur, %	0.08
Pour, °F.	20	Refr. Index (D line 20°C.)	1.4801
Flash, °F.	450	Aniline Point, °C.	111.4
Fire, °F.	490	Waterman Ring Analysis	
Kinematic Viscosity		Aromatic Rings, %	5.9
at 100°F.	66.99	Naphthenic Rings, %	19.7
at 130°F.	32.76	Parraffinic Chains, %	74.4
at 210°F.	8.69	Rings/Molecule	2.0

Apparatus

Details of an apparatus designed to measure the extent of bearing corrosion in a lubricating oil in the presence of air at 175°C. are shown in Figure 1. It is similar to the cadmium silver bearing corrosion test used in some lube oil laboratories and previously described in the pat-

ent literature (15, 16). Except for a few modifications the conditions used in our work were very similar. Air at the rate of two liters per hour, controlled by the pressure regulator system at C in Fig. 1, was

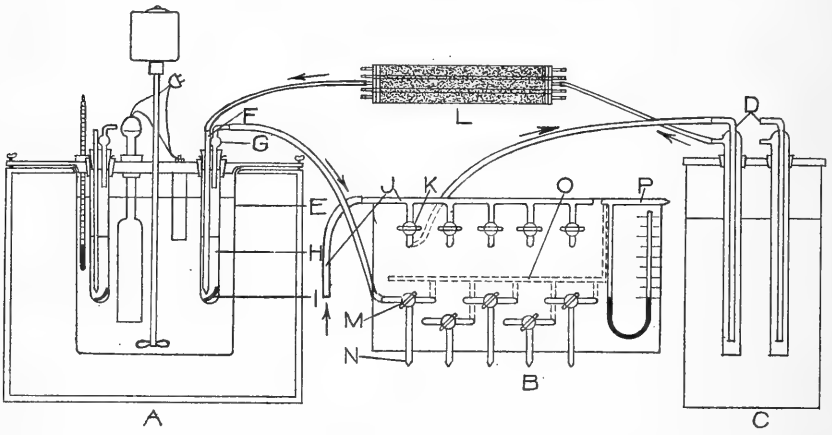

Fig. 1. Diagram of corrosion test apparatus.

blown into a 25-gram sample of oil at H for a period of twenty-two hours. Temperature of the oil samples was kept at 175°C. by means of a well-insulated constant temperature bath (A), equipped with a stirrer, 250-watt heater, thermometer, and thermoregulator (±0.5°C.). Extra heavy lubricating oil served as a heat transfer medium. A separate air supply for each sample entered the system at J, passed through a pressure regulator, D, a drying tube at L, thence to the test cell at E, and escaped through exit tube G and a glass jet at N. By means of a stopcock M the air current from the test cell E could be diverted through O to a flowmeter P.

The standard test piece used was one quarter of a Pontiac connecting rod bearing, 4 x 1.4 cm., weighing approximately 6 grams and having a surface of cadmium silver alloy. A clean, weighed strip (I in Fig. 1) was removed after completion of a run, washed with petroleum ether, dried at 120° C., and reweighed. The loss in weight before and after a determination was reported in milligrams (see Table II).

Experimental Results

Under the experimental conditions noted above, the blank oil whose properties are recorded in Table I gave an average bearing weight loss of about 18 mg. when no inhibitor was added. Table II summarizes the results obtained with the various sulfur compounds

TABLE II

RESULTS OF THE CORROSION TEST ON OIL SAMPLES CONTAINING SULFUR COMPOUNDS AS INHIBITORS[a]

Sulfur Compound Used as Inhibitor	Average Bearing Weight Loss in Mg.[b]
BLANK OIL (No inhibitor added)	18.0
MERCAPTANS	
1. n-Heptyl mercaptan, B.p. 174-6°	46.4
2. n-Octyl mercaptan, B.p. 201-3°	10.9
3. n-Nonyl mercaptan [g]	23.0
4. n-Undecyl mercaptan [g]	5.9
5. n-Dodecyl mercaptan, B.p. 146-8°/15 mm.	5.8
6. tert-Dodecyl mercaptan, [d] B.p. 78-87°/5 mm.	0.2 [e]
7. n-Tetradecyl mercaptan, B.p. 177-181°/21 mm.	3.1
8. n-Octadecyl mercaptan, B.p. 212-4°/15 mm.	0.3
9. Trimethylene dimercaptan, B.p. 66-8°/18 mm.	4.9
THIOPHENOLS	
10. Thiophenol, B.p. 62-3°/15 mm.	57.2
11. p-Thiocresol, M.p. 41-43°	58.6
12. o-Thiocresol, M.p. 10-12°	48.9
13. m-Thiocresol, B.p. 75-7°/10 mm.	65.5
14. p-Octadecyl thiophenol, M.p. 55-55.5°	0.2 [e]
15. β-Thionaphthol, M.p. 80-82°	45.1
SULFONES	
16. n-Heptyl sulfone, M.p. 79-79.5°	23.3
17. n-Octyl sulfone, M.p. 75-76°	12.0
18. n-Decyl sulfone, M.p. 83-84°	21.5
19. n-Dodecyl sulfone, M.p. 93.5-94°	20.6
20. n-Tetradecyl sulfone, M.p. 98-98.5°	24.7
21. n-Octadecyl sulfone, M.p. 105-106°	16.0
SULFIDES	
22. n-Heptyl sulfide, B.p. 143-145°/8 mm.	21.8
23. n-Octyl sulfide, B.p. 131-134°/1.8 mm.	21.7
24. 2-Octyl sulfide, B.p. 100-102°/1.7 mm.	8.5
25. n-Decyl sulfide, M.p. 24-25°	14.3
26. n-Dodecyl sulfide, M.p. 38-40°	17.5
27. n-Tetradecyl sulfide, M.p. 51-52°	11.6
28. n-Hexadecyl sulfide, M.p. 54-56°	7.4
29. n-Octadecyl sulfide, M.p. 66-68°	4.6
30. Phenyl β-hydroxy ethyl sulfide, M.p. 56-58°	77.7
31. n-Amyl β-hydroxy ethyl sulfide, B.p. 125-126°/10 mm.	45.5
32. Phenyl sulfide, B.p. 151-153°/15 mm.	17.7
DISULFIDES	
33. n-Butyl disulfide, B.p. 110-113°/15 mm.	26.5
34. n-Heptyl disulfide, B.p. 198-210°/22 mm.	2.1
35. n-Octyl disulfide, B.p. 180-186°/5 mm.	5.9
36. 2-Octyl disulfide, B.p. 125-129°/1.7 mm.	4.5
37. n-Decyl disulfide, B.p. 15-16°	2.7
38. n-Dodecyl disulfide, M.p. 26-27°C	2.8
39. tert-Dodecyl disulfide, B.p. 60-90°/0.2-0.3 mm	0.3 [d]
40. n-Tetradecyl disulfide, M.p. 44.5-45°	2.0
41. n-Octadecyl disulfide, M.p. 48-48.5°	0.1 [e]
MISCELLANEOUS	
42. Elemental sulfur	0.0
43. Ethylene sulfide polymer, M.r. 148-159°	0.4 [e]
44. Ethylene disulfide polymer, M.r. 98-115°	0.8 [f]
45. Hexamethylene sulfide polymer, M.r. 54-59°	1.4 [e]
46. Decamethylene sulfide polymer, M.r. 71-76°	7.0
47. 1,4-Dithiane, M.p. 112°	21.4
48. Methyl-n-amyl-1,3-dithiane, B.p. 140-142/15 mm.	9.9

[a] Each oil sample contained 0.2% sulfur from added inhibitor.
[b] Resulting from the average of two or more determinations after running for 22 hours at 175° C.
[c] All temperatures reported are Centigrade readings, uncorrected.
[d] Contained a mixture of isomers.
[e] Bearing showed a gain in weight.
[f] This sample contained only 0.1% sulfur instead of 0.2% as in others.
[g] Boiling range not listed by vendor's catalogue (Columbia Organic Chemicals Co.).

when they were used as inhibitors in amounts sufficient to give oil samples containing 0.2% sulfur on a weight basis. These quantities were equivalent to 0.0062 mole per 100-gram oil sample for compounds containing only one sulfur atom per mole, or 0.0031 mole for compounds with two sulfur atoms, etc.

For some of those compounds which caused little or no bearing weight loss, as indicated by results in Table II, a few additional corrosion tests were made with oil containing smaller amounts of the sulfur inhibitor. These results are indicated in Table III, and as in the previous tests they represent the loss in weight, in milligrams, of the cadmium silver bearing strip after contact with a 25-gramm oil sample for 22 hours at 175°C.

TABLE III

CORROSION TESTS ON SOME OIL SAMPLES WITH REDUCED AMOUNTS OF SULFUR INHIBITORS[a]

Sulfur Inhibitor[b]	Bearing Weight losses in Mg. for different concentrations of inhibitor[c]				
	0.2%	0.1%	0.05%	0.037%	0.025%
Ethylene sulfide polymer (No. 43[d])	0.4[e]	0.2[e]	3.6	11.6	19.2
Hexamethylene sulfide polymer (no. 45)	1.4	0.2	16.3	----	----
Decamethylene sulfide polymer (No. 46)	7.0	12.5	----	----	----
Ethylene disulfide polymer (No. 44)	----	0.8	7.2	----	----
tert-Dodecyl mercaptan (No. 6)	0.2[e]	24.1	----	----	----
p-Octadecylthiophenol (No. 14)	0.0	0.2	----	----	----
Elemental sulfur (No. 42)	0.0	0.2	0.1	1.0	----

[a]Results expressed as average weight loss in mg. for each different concentration of inhibitor used with conditions of time and temperature similar to those in Table II.

[b]Added to 25.g sample of base oil.

[c]Expressed in terms of weight percent of elemental sulfur.

[d]Numbers refer to compounds listed in Table I.

[e]Actually this represents a slight gain in weight of the bearing strip.

Some oil inhibitors may appear to be satisfactory from the standpoint of preventing or reducing the amount of corrosion of a cadmium silver bearing surface for a limited time, but they may be quite undesirable because they tarnish copper. Because of this, inhibitors are usually subjected to the copper strip test as a preliminary screening operation before other tests are actually carried out. A simple qualitative test is to permit a small sample of oil to remain in contact with a strip of copper for 24 hours at 100°C. without agitation by air or stirring. Such a copper tarnish test was made on some of the better sulfur-containing inhibitors shown in Tables II and III. The results of the copper strip test are listed in Table IV, giving the concentration of inhibitor expressed in terms of percent sulfur, and the extent to which the added substance attacked the surface of the copper strip.

Discussion

A systematic study has been made of the corrosion inhibiting effect of several different kinds of organic sulfur compounds when added to oil samples in quantities to give 0.2% or less sulfur by weight. The compounds listed in Table II can be divided roughly into three types: (1) those compounds which had no effect; (2) those which

TABLE IV

EFFECT OF SULFUR-CONTAINING INHIBITORS ON COPPER STRIPS

Sulfur Inhibitor	Per Cent Sulfur in Oil Sample	Effect on Copper	Sulfur Inhibitor	Per Cent Sulfur in Oil Sample	Effect on Copper
MERCAPTANS			SULFIDES		
tert-Dodecyl mercaptan (No. 6[a])	0.2	Severe[b]	n-Tetradecyl sulfide (No. 27)	0.2	Extremely slight
n-Tetradecyl mercaptan (No. 7)	0.2	Slight	n-Hexadecyl sulfide (No. 28)	0.2	Extremely slight
n-Octadecyl mercaptan (No. 8)	0.2	Considerable	n-Octadecyl sulfide (No. 29)	0.2	Extremely slight
DISULFIDES			MISCELLANEOUS		
n-Heptyl disulfide (No. 34)	0.2	Severe	Elemental sulfur (No. 42)	0.05	Severe
n-Octyl disulfide (No. 35)	0.2	Severe	Ethylene sulfide polymer (No. 43)	0.05	None
2-Octyl disulfide (No. 36)	0.2	Slight	Ethylene disulfide polymer (No. 44)	0.1	Considerable
n-Dodecyl disulfide (No. 38)	0.2	Considerable	Hexamethylene sulfide polymer (No. 45)	0.1	Slight
n-Tetradecyl disulfide (No. 40)	0.2	Slight	Decamethylene sulfide polymer (No. 46)	0.2	None
n-Octadecyl disulfide (No. 41)	0.2	Severe	p-Octadecylthiophenol (No. 14)	0.2	None

[a]Numbers in parenthesis refer to compounds listed in Table II.

[b]Extent of tarnish on copper strip indicated in following order: None, extremely slight, slight, considerable, and severe.

had a catalytic effect; i.e. caused a weight loss of more than 18 mg.; and (3) those which produced an inhibiting effect on the oil.

A few generalizations as follows can be made from this study:

(1) The corrosion inhibition effect of a particular type of compound usually became more pronounced with an increase in molecular weight; this was more noticeable with the sulfides, the mercaptans and the disulfides than with some of the other sulfur derivatives employed (see Figures 2-A and 2-B).

(2) All compounds tested which contained the octadecyl radical, with the possible exception of the sulfone, were quite effective as inhibitors of corrosion on cadmium silver surfaces; this was not necessarily true on copper, however.

(3) The mercaptans and disulfides which contained twelve or more carbon atoms per mole were found to be surprisingly good inhibitors of corrosion on cadmium silver but unfortunately they tarnished copper surfaces very badly.

(4) Our work, in general, supports some of the observations of Denison and Condit (7), namely that alkyl sulfides as a group are probably the best all-around inhibitors among the sulfur compounds tested; this is especially true if one includes the oil-soluble polymeric sulfides, such as ethylene sulfide polymer (No. 43 in Table II).

Figures 2-A and 2-B show the comparative inhibiting effect on cadmium silver surfaces of straight chain aliphatic sulfides, mercaptans and disulfides when the chain length, and hence the molecular weight, is increased. The polymethylene sulfide and disulfide polymers were not included in the graph. Those compounds which caused a

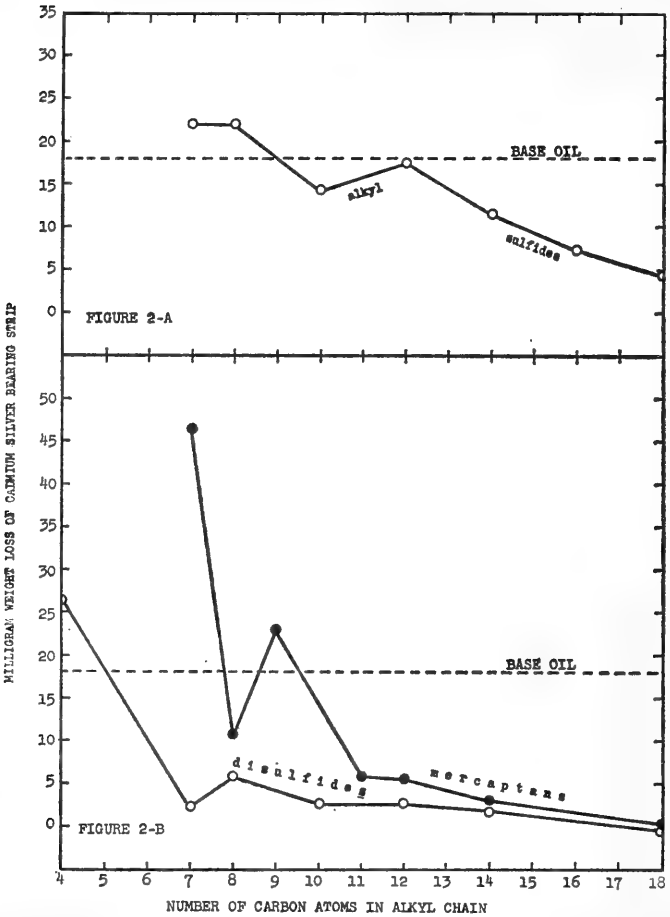

Fig. 2. Comparative inhibiting effect of straight chain sulfur compounds. A—Alkyl sulfides; B—Alkyl mercaptans and disulfides.

bearing loss above 18 mg. might be considered as catalysts for bearing corrosion. Figure 3 gives the corrosion rate curves from 0 to 22 hours for the straight chain aliphatic mercaptans. It is admitted that results might vary somewhat with different stocks of base oil used, but due to its low sulfur content it doubtless served our purpose very well.

It can be observed that the alkyl sulfides containing over twenty carbons per mole, the mercaptains and disulfides with at least twelve carbons per mole, the polymeric sulfur compounds, and a single thiophenol with an octadecyl group were fairly effective as inhibitors on cadmium silver. The sharp increase in the inhibiting effect of the higher molecular weight mercaptans was unexpected.

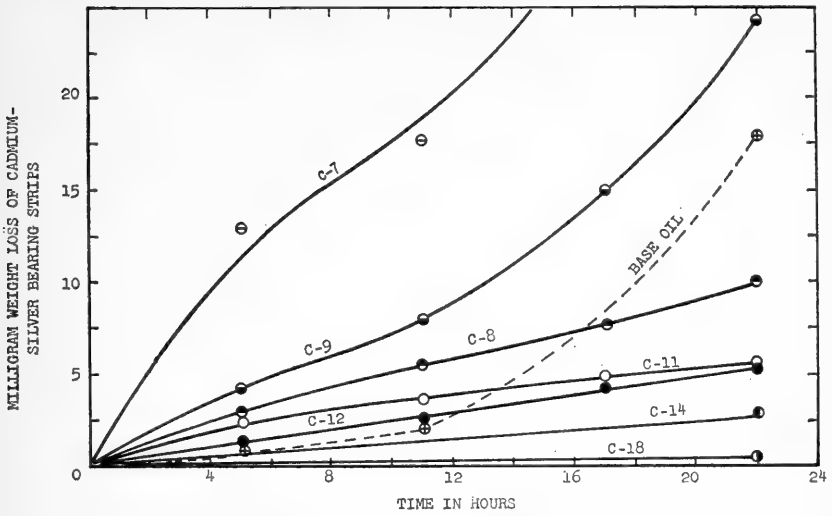

Fig. 3. Rate of corrosion curves for straight chain aliphatic mercaptans.

The alkyl sulfones were generally ineffective either as inhibitors or as catalysts for this type of corrosion test. This observation is in agreement with some of the results reported by Denson and Condit (7).

Although some results were obtainable for studying the effct of chain branching on inhibitor action in this particular base oil, one must exercise caution in making conclusions from the limited data which are available. There is some indication that branched alkyl chains were slightly more effective than the corresponding straight chain isomers.

Compounds listed in Table III were added to oil samples in quantities to give less than 0.2% sulfur. It can be observed that elemental sulfur was very effective at concentrations as low as 0.037%, and ethylene sulfide polymer (No. 43) was quite effective at 0.05% or even lower. p-Octadecylthiophenol (No. 14) gave favorable results at 0.1% concentration; unfortunately lower concentrations of this compound were not tried during the period of experimentation. Decamethylene sulfide polymer (No. 46) and tert-dodecyl mercaptan (No. 6) were not very effective when reduced from 0.2% to 0.1%. Hexamethylene sulfide polymer (No. 45) and ethylene disulfide polymer (No. 44) were effective at 0.1% but much less so at 0.50% concentration.

If compounds classed as inhibitors based on the Cd-Ag corrosion test are ruled out because they tarnish copper (copper strip test, Table IV), the number of satisfactory inhibitors listed in Table II

would be reduced considerably. In fact, this would eliminate all but the alkyl sulfides, the polymethylene sulfide polymers, and p-octadecylthiophenol. The latter compound probably deserves more study as an oxidation inhibitor for oils and is a type of compound which was mentioned in the work of Reid and Hamilton (16).

The mechanism of corrosion inhibition may be due to any one or a combination of various factors. The most probable are the following:

(1) Formation of a protective coating on the bearing surface.[4]
(2) Reduction of acid formation in the oil by furnishing basicity.
(3) Retard oil oxidation possibly by preventing the formation of peroxides.
(4) Reduction of peroxides, i.e. destroy the peroxides formed.

It has been demonstrated that the attack of oxygen on a hydrocarbon is a free radical chain reaction (19, 20). Denison (6, 7) has suggested that corrosion is a result of the ability of peroxides to convert metal into metal oxides which are subsequently removed by reaction with acidic constituents developed during oxidation. By a combination of these concepts, the mechanism of bearing corrosion may be illustrated by the following series of reactions:

A. Formation of peroxides through chain reaction

$$RH \text{ (activation)} \rightarrow R\cdot + H\cdot$$
$$R\cdot + O_2 \rightarrow ROO\cdot$$
$$ROO\cdot + RH \rightarrow ROOH + R\cdot$$

B. Corrosive action

$$ROOH + M \rightarrow ROH + MO$$
$$MO + 2HA \rightarrow MA_2 + H_2O$$

where M = Metal, ROOH = peroxide, and HA = organic acid.

Several authors (7, 21) have suggested that the best corrosion inhibitors are probably those which readily reduce hydroperoxides. Thus, a sulfide inhibitor might destroy a peroxide by reduction as follows:

$$ROOH + R\text{-}S\text{-}R \rightarrow R\text{-}SO\text{-}R + ROH$$
$$ROOH + R\text{-}SO\text{-}R \rightarrow R\text{-}SO_2\text{-}R + ROH$$

The oxidation products of the sulfide might be either a sulfoxide or a sulfone.

Our work has demonstrated that the sulfones as a group are quite inert as corrosion inhibitors for cadmium silver surfaces (see Table

[4] This might explain the slight increase in bearing weight noticed in a few instances and recorded in Table II.

II). This particular observation of ours lends much support to the Denison-Condit mechanism described above.

Summary

Alkyl sulfides, disulfides and mercaptans were more effective as oxidation inhibitors than sulfones as determined by the cadmium silver bearing corrosion test. Their effectiveness as inhibitors increased with molecular weight. Polymethylene sulfide polymers were most effective. With the exception of p-octadecylthiophenol, the thiophenols appeared to be more corrosive than the mercaptans. The tarnish effect on copper increased in the following order: polymethylene sulfide polymers, alkyl sulfides, alkyl disulfides and mercaptans. Some of our results lend support to the Denison-Condit idea of peroxide reduction in oils.

Acknowledgment

The authors wish to thank E. W. Fuller of the Research and Development Laboratories, Socony-Mobil Oil Company, for his valuable suggestions relating to corrosion tests, and also for the base oil which he supplied for this work.

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THE CAVE SNAIL, *CARYCHIUM STYGIUM* CALL

LESLIE HUBRICHT
1285 Willow Avenue, Louisville 4, Kentucky

Carychium stygium Call, was described from specimens collected in Mammoth Dome, Mammoth Cave, Edmonson County, Kentucky. (Call, 1897) Giovannoli (Bailey, 1933) found it in Buzzard's Cave and White's Cave, near Mammoth Cave. This remained the known range of the species until the present author found it to be widely distributed in the caves of central Kentucky. It was found in an area about 60 miles long, and about half as wide, extending from near Upton, Kentucky on the north to near Portland, Tennessee on the south. In this area it was found in most of the caves in which there was sufficient food and moisture. Efforts to find it outside of caves were unsuccessful; it was found only in the total darkness of caves.

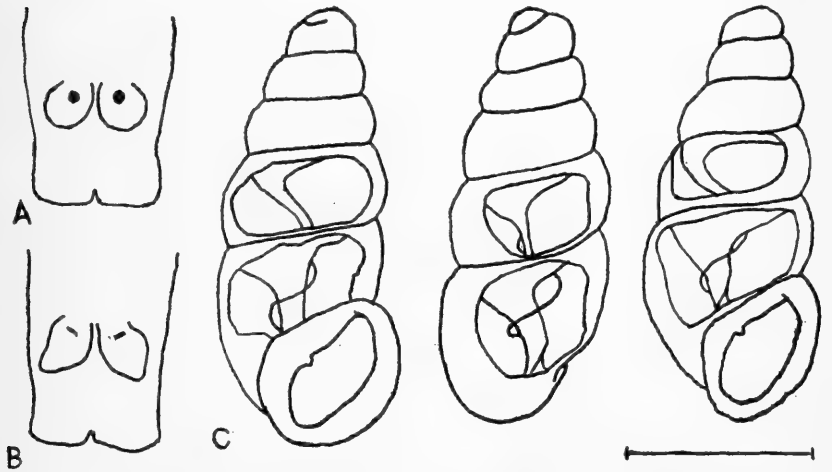

Fig. 1. *Carychium stygium* Call. Whites Cave. A. head of animal with round eyes and rounded tentacles. B. head of animal with degenerate eyes and pointed tentacles. C. three shells opened to show lamellae. Scale line equals 1 mm.

Localities:

KENTUCKY: Hart County: Copelin Cave, 2 miles east of Millerstown; Puckett Cave, 1 mile west-southwest of Priceville; Chattin Cave, 2 miles west of Priceville; Cooch Webb Cave, 2.2 miles west of Priceville; Buckner Hollow Cave, 7 miles east-northeast of Munfordville (Thomas C. Barr, Jr., Coll.); Cub Run Cave, 2 miles west of Cub Run; Ronalds Cave, 2.6 miles north of Cave City; Hogan Cave, 3 miles north of Cave City; cave, 2 miles southwest of Northtown. Edmonson County: near river in Great Onxy Cave; Cathedral (Buzzards) Cave, near Floyd Collins Crystal Cave. Mammoth Cave National Park: Pogoda Cave; Salts

Cave, near old Pike Chapman Entrance; Whites Cave; Little Whites Cave; Dixon Cave; Proctors Cave; Martins Cave; Running Branch Cave; Blowing Spring Cave; small cave near Longs Cave; Mammoth Cave: Bunker Hill, end of Audubons Avenue; Mammoth Dome; near Richardson Spring; River Hall; Violet City; Cathedral Domes; New Entrance; Frozen Niagara. Barren County: Indian Cave, 4 miles west of Cave City; Railroad Cave, Cave City; Burnett Cave, 0.6 mile west of Park City; Vance Cave, 0.8 mile northwest of Park City; Brushy Knob Cave, 2 miles northwest of Park City; Diamond Cavern, 2 miles north of Park City (fossil only); Short Cave, 2.2 miles northwest of Park City; Beckton Cave, 0.5 mile northwest of Beckton; Duval Saltpeter Cave, 0.7 mile northwest of Beckton; Cave Spring Cave, 1 mile south-southwest of Red Cross. Warren County: Bypass Cave, Bowling Green; Vails Cave, 2 miles west of Bowling Green. Simpson County: Hoy Cave, 2 miles north of Franklin; Steeles Cave, 4 miles southeast of Franklin. TENNESSEE: Sumner County: small cave in sink above White Oak Cave, 2.2 miles east-northeast of Mitchellville.

Considering the isolation of the colonies, there is remarkably little variation. In shell size, the over-all variation is only slightly greater than that to be found in a single colony. (Fig. 2). The largest shells were found in Mammoth Cave and other caves in the vicinity. They become slightly smaller at the northern and southern limits of the range. In the shells opened there was very little variation in the internal lamellae. The principal lamella has an even spiral edge and is rather small. The columellar lamella is obsolete (Fig. 1C).

In the animals examined the tentacles were either bluntly pointed (Fig. 1B) or lobed (Fig. 1A), the latter being in the majority. The eyes are situated in the base of the tentacles and are usually round (Fig. 1A), but sometimes are reduced to an irregular mass of dark pigment (Fig. 1B).

The question of how *Carychium stygium* became distributed in the caves in which it is found is as yet unanswered. That this snail, whose movement is so slow as to be barely perceptible, could crawl from a single point of origin through subterranean passageways into the many caves in which it is now found seems improbable. It seems more probable that it was originally a surface species which moved indepently into each of the cave systems in which it is now found. The absence of variation and the presence of eyes would indicate that either the migration into the caves has been rather recent or that the snails have an unusually stable gene system.

Much has been written about the uniformity of the cave habitat. While it is true that temperatures and the absence of light are constant, other important factors, such as moisture, food supply, and the prevalence of competitors and predators, may vary widely. Some caves are quite wet, with dripping walls and ceilings, often with stalactites and stalagmites. These usually have an abundant fauna if food is available. Others are subject to flooding after heavy rains; these caves usually do not have as abundant terrestrial fauna as the first type.

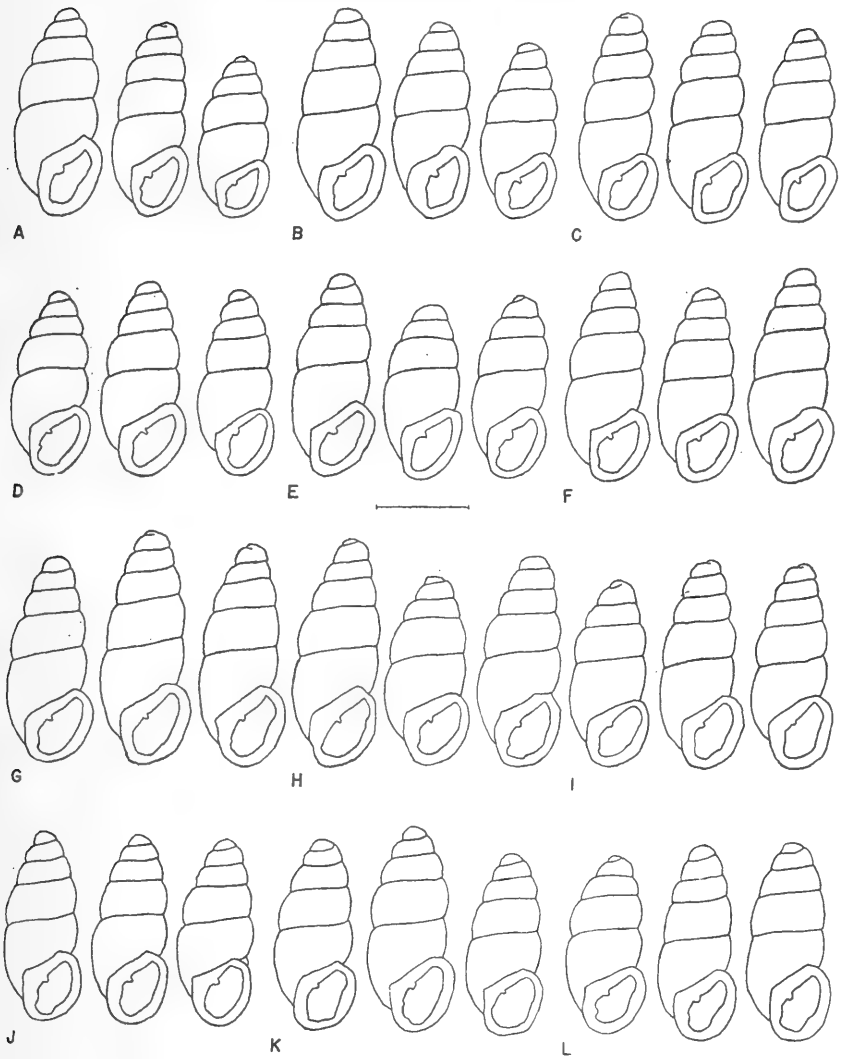

Fig. 2. *Carychium stygium* Call. A. Copelin Cave. B. Cooch Webb Cave. C. Buckner Hollow Cave. D. Cub Run Cave. E. Ronalds Cave. F. Hogans ave. G. Mammoth Dome, Mammoth Cave. H. River Hall, Mammoth Cave. I. Brushy Knob Cave. J. Duval Saltpeter Cave. K. Bypass Cave. L. Steeles Cave. Scale line equals 1 mm.

Still others may be relatively dry, and usually have a meager fauna. There are two principal sources of food supply; debris washed in by streams; and the guano of bats, cave rats (*Neotoma*), and cave crickets (*Hadenoecus*).

My observations indicate that while *Carychium stygium* will feed on leaves and wood where it is available, the principal food is the

guano of the cave cricket (*Hadenoecus subterraneus* Schudder). They have not been observed feeding on either bat or cave rat guano. In most caves there is a direct correlation between the number of cave crickets and the abundance of *Carychium stygium.* Since the cave crickets usually must go outside of the caves at night to feed, they are not found in abundance very far from an opening. *Carychium stygium* is usually found near the entrance (but in total darkness), or in the vicinity of breakdowns. In Mammoth Cave they are found in the deeper parts of the cave only in River Hall, where they appear to feed on mud and slime brought in by the annual floods.

Usually associated with *Carychium stygium,* in addition to *Hadenoecus subterraneus,* are the cave millipede *Scoterapes copei* (Packard), the bristle-tail *Campodea cookei* Packard, and the beetle *Ptomaphagus hirtus* (Tellkampf). These are guano feeders and compete with *Carychium stygium* for food. The harvestman *Phalangodes armate* Tellkampf, the spider *Antrobia mammouthia* Tellkampf, and the beetles *Neophaenops tellkampfi* (Erichson), and *Pseudanophthalmus* spp. are predators. Whether any of these prey upon *Carychium stygium* is doubtful. None was seen to show any interest in the snails.

Carychium stygium requires a very moist habitat and drought is fatal. On the other hand, it seems to be able to stand submergence in water for long periods. It was found crawling about on the wet mud after a flood in River Hall, Mammoth Cave. In White's Cave it was seen crawling about on the bottom of a pool where there had been water for several months.

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APPLICATIONS OF SOLAR ENERGY

K. V. PRASANNA
Illinois Institute of Technology, Chicago, Illinois

The amount of energy radiated at the sun's surface is about twenty million B.T.U. per square foot per hour. Of this, the energy received at the outer edge of the earth's atmosphere amounts approximately to two thousandths of one per cent (0.002%). A maximum of forty percent of this energy intercepted could be collected at the earth's surface, the remainder being absorbed and scattered in the atmosphere. All the deposits of coal and oil comprise a very small fraction of this energy stored over millions of years. Water situated at high potential is another form of the sun's energy. Fuel alcohol obtained from certain vegetable matter is yet another form of stored energy.

If all the stored energy that could be recovered from the earth were stock piled, it would amount only to a three-day period of solar energy intercepted by the earth. It has been estimated that the energy consumed during the past fifty years corresponds nearly to eighty percent of all the energy ever consumed by Man. According to very reasonable estimates of the future power requirements, all the present energy, including atomic energy, will last for only 245 years. By 2200 A.D. Man must be able to harness one percent of the solar energy received by the earth to cope with his power requirements.

Even the most modern equipment operating on present fuels corresponds to sixteen hundredth of one percent of the energy received. It is needless to mention the efficiency of the equipment used by our predecessors. Let us consider the familiar example of the domestic animal the bull, which is still a chief source of motive power used by the agriculturists of India. An average Indian bull can exert a force of sixteen hundredth (0.16) of a ton for eight hours, the power of the bull being 720 watts for that period. The average power utilized is only a third of this, that is 240 watts for eight hour period. The average for a twenty-four hour day is only eighty (80) watts per hour. On the other hand, the average minimum consumption of food is nineteen pounds of dry hay per day, a heat equivalent of 1500 watts. A steam engine operating on the same fuel can develop one hundred and eighty (180) watts. These figures show how inefficiently we are utilizing our resources.

If a power plant were to be built utilizing the solar energy received on 750 square miles of desert land in the United States, it could cater to the present power requirements. A power plant covering one-

fifth of the area of the state of New Mexico can supply thirty times the present power requirements of the United States.

If the harnessing of solar energy is broken into its elements, it falls into four branches: collection, transportation, storage and utilization. Let us consider the influence of each of these factors.

The amount of solar energy received on any part of the earth's surface depends on:

(1) the hour angle of the sun
(2) the declination
(3) the latitude of the place
(4) the solar altitude above the horizon
(5) the azimuth of the sun
(6) atmospheric conditions like air mass factor, cloud, and haze factor, diffuse radiation factor
(7) the position of the energy receiving surface.

It is observed that, at the outer edge of the earth's atmosphere a maximum of 4300 B.T.U. per square foot of normal area for a day of ten hour sunshine, can be received. The average amount of solar energy at any place is given by 4300 multiplied by all the above said factors. According to U.S. Weather Bureau reports, near the Boston area, minimum average incident solar energy is 1000 B.T.U. per square foot of south wall area per day. This figure is greater as we go towards the equator. The threshold value of incident solar energy below which it cannot be collected is thirty B.T.U. per square foot per hour which corresponds to 4.3% of daily total energy received.

The amount of solar energy that could be collected depends on the efficiency of collectors and the temperature of collecting surface above that of the environment. The type of collector depends on the particular application. For water and space heating, a flat plate collector can be used in which a temperature as high as 195°F has been attained. For conversion of solar energy into power a higher temperature difference is necessary. For this a mirror type collector is used in which a temperature as high as 8500°F has been attained. However, to keep the radiation losses to a minimum, a smaller temperature difference is advisable.

A blackened flat copper plate, when used as a collector, has an absorption efficiency of ninety-five percent, but external radiation losses bring down the net collection efficiency to a low value. Introduction of a glass cover plate reduces the incident solar energy by a small amount, but it reduces radiation losses to a great extent, thus increasing the collector efficiency. Experimental investigation has shown that up to a maximum of three glass cover plates with air

spaces in between, improves collector efficiency considerably, the value of the efficiency in this case being fifty-seven percent.

For concentration of solar energy by mirrors a concave or a parabolic mirror can be used. However, from the cost consideration it is economical to build the collector using pieces of flat mirrors with proper orientation.

It is needless to say that the transportation and storage losses should be kept at a minimum by the use of proper insulation so that overall efficiency of solar equipment can be kept at a high value.

Utilization of Solar Energy

The term utilization factor is defined as the ratio of energy available in the required form, to the amount of solar energy incident on the collector. Experimental investigations have shown that utilization of solar energy as heat, is far more efficient than other forms of energy like mechanical and electrical energy, since the latter usually involves heat as an intermediate stage. The utilization factor is as low as five tenths of one percent (.5%) in photonynthesis. It has reached a peak of thirty-two percent (32%) for space heating, which figure is considerably greater than that obtainable from other forms of energy whose ultimate source is solar energy.

Egyptians were one of the pioneers in utilizing solar energy for heating water and operating irrigation pumps. In the year 1818, the first steam engine operated completely by solar energy was built in France. It produced one horse power utilizing twenty square yards of collector area. A modified solar steam engine was built in 1878 which operated a complete printing press. In 1868, a solar furnace for melting copper was built. A solar steam engine built at South Pasadena, California operated a water pump, with a discharge capacity of 1000 gallons per minute.

In more recent years several devices harnessing solar energy have been built all over the world. In Algiers a solar furnace equipped with twenty-seven and a half foot diameter parabolic mirror, synthesizes nitric acid directly from air, water, chalk and sunshine. In Pyrnees, France a forty foot mirror produces refractory ceramics such as fused quartz and titanium oxide on a commercial scale. Convair's at San Diego, have built a solar furnace using one fourth inch aluminum plate bent into parabolic shape. The ten foot diameter mirror focuses the sun's rays to a hot spot five sixteenths of an inch in diameter at thirty-four inches from the center of the mirror.

The temperature attained is 8500°F as compared with a maximum temperature of 5800°F attained by oxy-acetylene torch. Dr. C. F.

Kettering has developed a photo-electric cell converting directly light into D.C. current which runs a small electric motor. Solar batteries developed by Bell laboratories, use ultra-pure silicon strips one inch by four inches (1″ x 4″) impregnated with one ten thousandth of an inch (0.0001″) boron. It is between these two surfaces transistor action takes place which results in flow of current. When several such elements are electrically connected, the battery is capable of giving a high current at a high voltage. The utilization factor for these batteries is eight percent. Now these batteries are commercially used for battery charging and in telephone circuits. The National Physical Laboratory of New Delhi, India has built an engine completely operated by solar energy. The same laboratory has built a solar cooker using a mirror type collector. Another type of cooker that can be used indoors uses heat absorbed by the fluid. Similar cookers have been developed at M.I.T., Massachusetts, and Japan. According to Russian claims, giant reflectors operate textile factories; high pressure solar heaters cook fruits and vegetables in canneries; distill water, make ice and heat laboratories. Yet another application is the use of solar energy for hot-water heating. Hot-water heaters have been successfully built both in California and Florida. A temperature as high as 140°F has been attained.

Solar Energy for Space Heating

One of the most feasible and economical application of solar energy for the present day, is its utilization for home heating. Experimental houses have been built in several parts of the United States to get an idea as to the various factors that influence space heating. The U.S. Weather Bureau over several parts of the country is regularly collecting data as to the amount of energy received by the earth.

Maximum energy can be collected when the collectors are normal to the angle of incidence of the sun's rays. It is almost impossible to achieve in practice since the angle of incidence is always changing. The best possible location of the collector for winter months, is at the south facing the roof inclined at sixty degrees to the horizontal. This has a disadvantage because of the accumulation of snow. To overcome the above disadvantage, collectors can be located at the south facing the vertical wall. This reduces the incident energy by ten percent but has the added advantage of collecting reflected solar energy during bright snowy days.

Purdue University at Lafayette, Indiana, was the first to build an experimental solar house to investigate the possibility of using solar energy for space heating. The house built had the upper two thirds

of the entire south wall covered with glass. The roof overhang was so adjusted that it allowed maximum exposure to sunlight during winter and completely cut-off the sunlight during summer. The experimental facts showed that excess loss through the added glass area during the dark period was more than the energy gained during bright sunny day. The drawbacks were: (1) not covering the glass area by an insulated partition during the period when there was no solar energy gain, (2) not providing a means of storage when the energy received was in excess of the requirement.

Dr. Maria Telkes at M.I.T. made an exhaustive investigation of several methods of storing systems with a view to building a successful solar house. The chief properties used were specific heat and latent heat of substances. Of all the substances, water has maximum specific heat, which permits maximum storage of heat for a given weight. On equal volume basis, it has a slight advantage since its specific weight is low. Experiments showed that due to excessive heat losses, it is not economical to store heat at a temperature higher than 100°F. Latent heats of melting of several chemical salts which lie in the range of 80 to 100°F can be used to a great advantage since a large amount of heat can be stored at constant temperature. One such salt is sodium sulphate, or commercially known as salt cake. The melting point of sodium sulphate is 90°F and the latent heat is 104 B.T.U. per pound. At the melting point most of the sodium sulphate melts in its own water of crystalization leaving only a small part of anhydrous salt. For instance, between 80°F and 100°F sodium sulphate can store 11,000 B.T.U. per cubic foot. To store the same amount of heat eight and a half cubic foot of water is necessary, which means larger space requirements. The impure sodium sulphate is quite cheap and cost of installation compares favorably with other types of specific heat storage. Possibility of storing a large quantity of heat at a constant temperature is of very great advantage for space heating. Inner corrosion can be prevented by the use of corrosion resistant materials. The heat receiving coil can be designed to prevent the settling of solid to the bottom by providing temperature stratification. Catalyst may be added to promote melting and recrystalization. The slight increase in volume during melting may be taken care of by partially filling the container. Salt packed in small containers is more economical and advantageous.

Figure 1 shows the cross section of a house having a large south wall glass area which almost corresponds to one built at Purdue University. In the vicinity of the Boston area during the winter months, on an average, the incident solar energy is 1000 B.T.U. per square foot

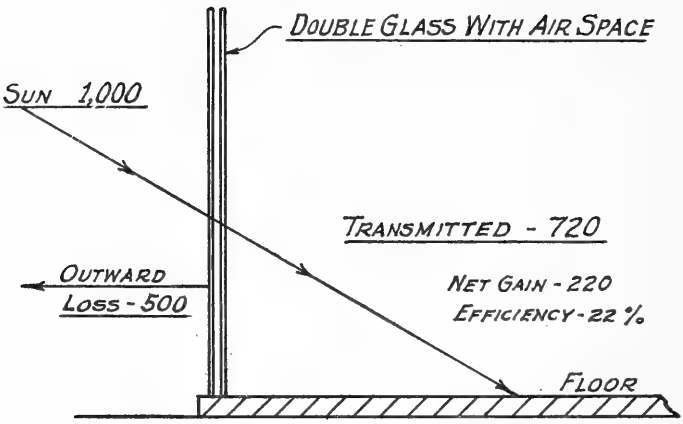


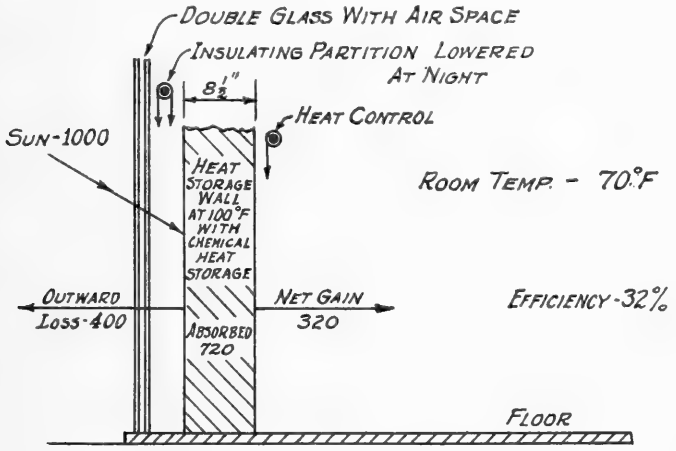
FIG. 1 - SOLAR HOUSE WITH LARGE WINDOWS

of south vertical wall area per day. Energy transmitted through the double glass wall with air space is 720 B.T.U. per square foot per day. The outward heat loss is 500 B.T.U. per square foot per day leaving a net gain of 220 B.T.U. per square foot per day. On clear days there will be more gain of energy, overheating the house, and on cloudy days there will be more external loss which necessitates auxiliary heating.

Figure 2 shows a similar house equipped with a chemical heat storage, using sodium sulphate as the chemical. The house is equipped with an insulating partition which is lowered during nights and dull days, reducing outward losses. The insulating partition at the inner end controls the room temperature at 70°F. For the same incident conditions the outward loss is 400 B.T.U. per square foot per day, and the net gain is 320 B.T.U. per square foot per day. Eight and a half inches represents the width of storage wall necessary to heat a four room house, the entire south wall being covered by the collector. By the figure it is apparent that this arrangement has the advantage of controlling the room temperature, added to increased utilization efficiency attained.

Figure 3 indicates improvement over the ordinary type of storage wall. The insulation wall in between collector and storage reduces the outward loss. The hot air circulation system ensures a better way of transmission of energy absorbed. The outward loss in this case is reduced to 350 B.T.U. per square foot per day increasing the net gain to 370 B.T.U. per square foot per day.

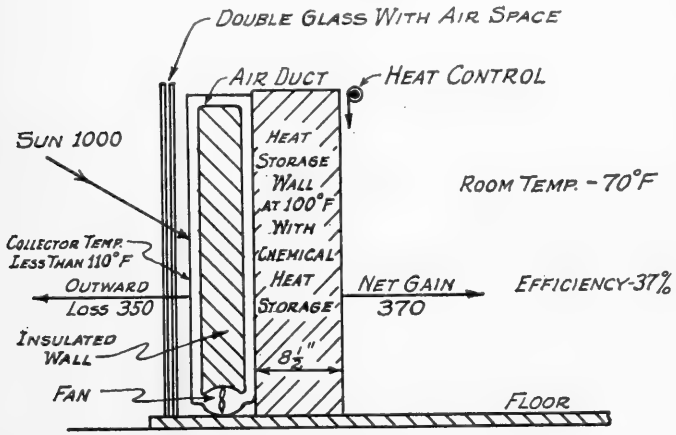
Utilizing these principles of storage systems, M.I.T. built a solar house which was completely heated by solar energy. The excess heat collected during clear winter days was stored in large storage bins to provide heat for intermediate spans of cloudy days when there was no gain of solar energy. Experimental investigations showed that it is economical to build storage bins as an integral part of the house,



FIGURES ARE IN BTU PER SQ. FT. PER DAY

FIG. 2 - SUN WALL WITH CHEMICAL HEAT STORAGE

CHEMICAL - GLAUBER'S SALT (Na_2SO_4 $10H_2O$)



FIGURES ARE IN BTU PER SQ. FT. PER DAY

FIG. 3 - WALL TYPE CHEMICAL HEAT STORAGE

CHEMICAL - GLAUBER'S SALT (Na_2SO_4 $10H_2O$)

situated in between two rooms to be heated. With this the radiation losses of the bins can be used to heat the rooms, raising the utilization efficiency. It was felt that, to equip the house with a complete solar heating system, to take care of long, infrequent, no sunshine days, necessitates the building of large storage bins. To overcome this disadvantage, it was felt that the house should be provided with any of the present day equipment as an auxiliary unit.

Several advantages can be attained by the installation of an auxiliary heat pump using air water or earth as a heat source, along with solar collectors. Provision of a higher heat source improves the efficiency of the heat pump. The temperature of collection need not be as high as any of the previously described systems since the heat pump acts as a booster and raises the collector's efficiency. The excess heat collected can be stored in the earth (in the case of an earth heat pump), saving the cost of storage equipment. There is no necessity to build the collectors as an integral part of the house. During summer the solar collectors can be used for hot water heating and the heat pump can be operated on the cooling cycle for summer air-conditioning. In the future, if all the American homes were equipped with solar heating systems, the energy saved would be more than fifty percent of the total American fuel consumption.

Today it is not impractical to think of a solar engine even up to a capacity of five horsepower which is quite a handy piece of equipment in an American farm home. Figure 4 shows a typical solar engine that can be built for such purposes. The solid line shows a freon-12 cycle and the dotted line shows a water cycle. The water cycle is equipped

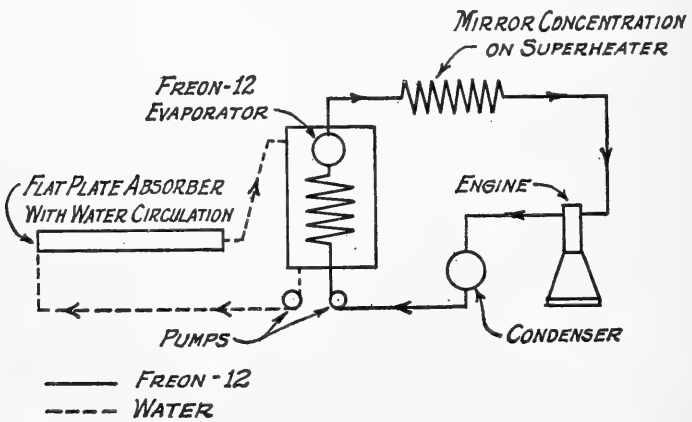


FIG. 4 – TYPICAL SOLAR ENGINE

with a pump to circulate, and a flat plate absorber to heat the water. The hot water passes through a heat exchanger evaporating freon in the evaporator. The freon vaper passes through a super heater equipped with mirror concentration. The super-heated vapor expands through an engine generating useful power. The exhaust vapor passes through a condenser and a circulating pump back to the evaporator.

Another possible application is the use of solar energy for summer air conditioning. Figure 5 shows a typical solar air-conditioner. At-

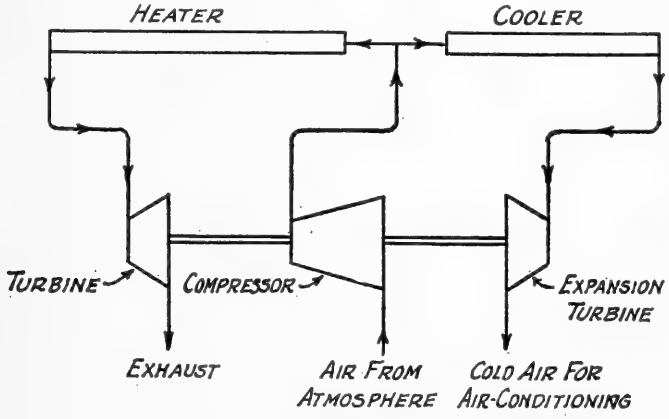


FIG. 5 – TYPICAL SOLAR AIR-CONDITIONER

mospheric air is drawn into a compressor and compressed to a high pressure. A small part of this high pressure air passes through a solar heater equipped with mirror concentration. The air at high pressure and temperature, passes through a turbine, which provides motive power for the compressor. The major part passes through a conventional water cooler. The cool high pressure air passes through an expansion turbine, with a further drop in temperature. The expansion turbine provides additional power for the compressor. The cold air coming out of the expansion turbine is available for air conditioning and human comfort.

The ever increasing power requirements of the modern man and the limited power resources at his disposal will certainly provide a great incentive to the already curious scientific investigator to explore successfully the possibility of harnessing the everlasting sun's energy for his power requirements. Before long, the economical barrier that is still enshrouding the development will break down and we will see man utilizing solar energy for his power requirements, not to mention the small innumerable household appliances. Very soon historians will

have to change the statement that, the prosperity of a nation depends on its coal deposits, to the prosperity of a nation depends on the extent to which it can harness the mighty and inexhaustible solar energy.

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SOIL TEMPERATURE MEASUREMENTS AT LEXINGTON, KENTUCKY FROM 1952 TO 1956

E. B. PENROD, J. M. ELLIOTT, and W. K. BROWN
Department of Mechanical Engineering, University of Kentucky, Lexington, Ky.

Soil temperature variation with time and depth is of interest to the design and maintenance engineer and agronomists. The annual variation of ground temperature must be taken into consideration by engineers in designing buildings, dams, highways, airport runways, water mains, pipelines, underground high voltage cables, and ground coils for earth heat pump installations. The extent of interest in soil science in recent years can be obtained readily by referring to the publications listed in the Bibliography.

Research In Geophysics

Research in geophysics was started at the University of Kentucky in 1949 when an earth heat pump system was employed to determine the thermal diffusivity of a clayey soil immediately west of Anderson Hall [4, 5].[1] The soil is covered with sod and has a general Casagrande classification of lean clay with low plasticity characteristics. The experimentally determined values of the thermal diffusivity and density of the soil are 0.019 $ft^2\ hr^{-1}$ and 120 lb. ft^{-3} respectively, and the calculated values of the specific heat and thermal conductivity of the soil are 3.37 B $lb^{-1}\ F^{-1}$ and 0.84 B $hr^{-1}\ ft^{-1}\ F^{-1}$ respectively. The specific heat of a sample of dried clay, taken from the earth near the ground coil of the heat pump system, was determined by the use of a special calorimeter [13]; the specific heat and density of the dried clay were found to be 0.196 B $lb^{-1}\ F^{-1}$ and 95 lb ft^{-3} respectively. From these values, the specific heat of the wet clay was calculated to be 0.37 B $lb^{-1}\ F^{-1}$.

Thermal properties of a sample of fine clay were determined in a single transient heat flow laboratory experiment [16]. The clay was taken at a depth of about six feet, east of Anderson Hall during an excavation for a new building, and was dried in an oven at 230° F. The physical properties, of a portion of the dried clay that passed through a No. 10 sieve, are:

thermal diffusivity	0.0075 $ft^2\ hr^{-1}$
thermal conductivity	0.123 B $hr^{-1}\ ft^{-1}\ F^{-1}$

[1] The numbers in brackets refer to research papers and reports listed in the Bibliography.

specific heat	0.204 B lb^{-1} F^{-1}
density (dry)	80.5 lb ft^{-3}.

Geophysical studies at the University of Kentucky, also, include soil temperature measurements and the determination of solar energy received on a horizontal surface [19, 24]. The empirical equations, developed for calculating soil temperatures at any time and depth, are based on soil temperatures taken at depths of 0, 2, 4,[2] 5, 6, 8 and 10 ft. west of Anderson Hall. The thermocouple used to determine the *surface* temperature was buried beneath the sod at a depth of about one-half of an inch. Soil temperatures have been recorded at two-hour intervals since 1952.

Empirical Equations

The surface temperature of the earth undergoes an annual temperature change that is nearly simple harmonic. It is often desirable to have an equation that can be used in calculating soil temperatures at any depth for a particular time. To derive an equation, it is assumed that the soil at a given locality is uniform, its surface is flat; and that heat flows in a direction perpendicular to the surface [19]. It is then only necessary to solve the Fourier heat equation

$$\frac{\partial t}{\partial \tau} = \alpha \frac{\partial^2 t}{\partial x^2} \,, \tag{1}$$

subject to the boundary condition

$$t = t_a \sin \frac{2\pi}{P} \tau \,, \tag{2}$$

where t = temperature, t_a = temperature amplitude, τ = time, P = period, α = thermal diffusivity, and x = distance from the surface. A particular solution of Eq. (1) is given by the equation

$$t_x = t_m + t_a e^{-x\sqrt{\pi/\alpha P}} \sin\left[\frac{2\pi}{P}(\tau - \tau_o) - x\sqrt{\frac{\pi}{\alpha P}}\right] \,, \tag{3}$$

where t_x = temperature at any distance x from the surface, t_m = mean surface temperature and/or mean soil temperature, τ_o = the time interval between the middle of a designated month and the date that the surface temperature is equal to the mean temperature [19].

The following equations were developed, from recorded tempera-

[2] The thermocouple used to obtain temperatures at a depth of 4 ft. ceased to function in November, 1953.

ture data, for calculating soil temperature, in °F, for any chosen time and depth for the five year period under consideration:

$$\underline{1952}$$

$$t = 58.08 + 20.54 e^{-0.109x} \sin(30^\circ\tau - 10.65^\circ - 6.25^\circ x),$$

$$\underline{1953}$$

$$t = 58.28 + 18.83 e^{-0.0909x} \sin(30^\circ\tau - 26.23^\circ - 5.21^\circ x),$$

$$\underline{1954}$$

$$t = 59.01 + 23.50 e^{-0.127x} \sin(30^\circ\tau - 10.38^\circ - 7.28^\circ x),$$

$$\underline{1955}$$

$$t = 56.86 + 26.25 e^{-0.135x} \sin(30^\circ\tau - 16.71^\circ - 7.73^\circ x),$$

$$\underline{1956}$$

$$t = 56.48 + 21.88 e^{-0.121x} \sin(30^\circ\tau - 12.78^\circ - 6.92^\circ x),$$

$$\underline{\text{and the 1952–1956 norm}}$$

$$t = 57.75 + 21.35 e^{-0.113x} \sin(30^\circ\tau - 15.72^\circ - 6.49^\circ x),$$

where $\tau = 0, 1, 2, \ldots$, on April 15, May 15, June 15, . . ., and x is the numerical value of the depth of soil.

Example.—As an application of the above equation for the five year norm, the soil temperature, say, at a depth of 13 ft. is desired on September 30, 1961. For this depth and time, $x = 13$ and $\tau = 5.5$. Substituting 13 and 5.5 for x and τ in the equation, the soil temperature is found to be 62.2° F. This value, of course, is for the type of soil in question, and will be approximately the same for a similar clayey soils, providing the latitude and climatic conditions do not vary greatly from those at Lexington.

Results

Using methods similar to those given in Reference 19, values of the mean soil temperature, surface soil temperature amplitude, and average thermal diffusivity were determined and are recorded in Table 1. Calculations were made also, to determine the variation of

Table 1.— Summary of Data for the Five Year Period at Lexington, Kentucky.

	Year					
	1952	1953	1954	1955	1956	Norm
Mean soil temperature, °F.	58.08	58.28	59.01	56.86	56.48	57.75
Mean air temperature, °F.*	56.67	57.80	57.05	55.78	55.71	56.55
Surface (soil) temp. amplitude, °F.	20.54	18.83	23.50	26.25	21.88	21.35
Air temperature amplitude, °F.	20.70	21.90	22.25	22.60	21.70	21.83
Total precipitation, inches/year*	40.99	39.15	35.53	47.31	52.15	42.97
Average solar energy, Btu/ft²/day	1534.58	1584.66	1617.84	1595.69	1567.51	1580.05
Average thermal diffusivity, ft²/hr	0.0301	0.0433	0.0222	0.0197	0.0245	0.0279

*Data supplied by the U.S. Weather Bureau, Blue Grass Airport, Lexington, Kentucky.

soil temperatures with time and depth. These results are presented graphically in Figures 1 to 9.

By the method of trial and error, the following equation was developed, using observed air temperatures taken and recorded at the U.S. Weather Station at the Blue Grass Airport, Lexington, Kentucky, for the five year period, 1952-1956:

$$t_{air} = 56.55 + 21.83 \sin(30^\circ \tau - 2^\circ 52'),\ ^\circ F,$$

where $\tau = 0, 1, 2, \ldots$, on April 15, May 15, June 15, ... Calculated and observed air temperatures are listed in Table 2. The agreement of the air temperatures calculated by the use of the above equation and the observed values is very good.

In Table 3 are listed calculated and observed soil temperatures. The agreement between the calculated and observed soil temperatures are excellent, except near the earth's surface which is subjected to sudden changes in weather. In developing the empirical equation the assumption, that the surface soil temperature varied in a sinusoidal manner, is approximately true. The area between the arch of the sine-surface temperature curve (Fig. 1) and the mean temperature axis from May to November is, of course, equal to that for the following six months. Of the total annual solar energy received by the earth's surface at Iexington, 66 per cent is received from May to November and only 34 per cent during the following six months. As a result of this, and probably other conditions, the area between the mean temperature axis and the curve (not shown in Fig. 1), for the observed surface soil temperatures for the period, November to May, is less than the area corresponding to the period, May to November.

Table 2.— Observed and Calculated Air Temperatures for the Five Year Norm, 1952-1956, at Lexington, Kentucky

Date	Time	Observed* air temp.°F.	Calculated air temp.°F.	Difference between obs. and cal. temp.°F.
April 15	0	55.46	55.46	0
May 15	1	66.51	64.80	1.71
June 15	2	74.89	74.30	0.59
July 15	3	78.35	78.14	0.21
Aug. 15	4	75.98	76.66	0.68
Sept. 15	5	68.40	69.98	-1.58
Oct. 15	6	57.64	57.76	-0.12
Nov. 15	7	46.59	44.34	2.25
Dec. 15	8	38.21	37.30	0.91
Jan. 15	9	34.75	35.42	-0.67
Feb. 15	10	37.12	39.64	-2.52
Mar. 15	11	44.70	44.84	-0.14
April 15	12	55.46	55.46	0
Average		56.55	56.55	

*Data taken at the Blue Grass Airport, Lexington, Kentucky by the U.S. Weather Bureau.

Table 3.— Calculated and Observed Soil Temperatures for Lexington, Kentucky for 1952*

	Temperatures in degrees F. at depths of											
	0ft		2 ft		5 ft		6 ft		8 ft		10 ft	
Month	Calc	Obs	Calc	Obs	Calc	Obs	Calc	Obs	Calc	Obs	Calc	Obs
Jan. 15	37.89	41.41	42.90	44.56	49.25	48.73	50.96	49.92	53.87	52.44	56.08	54.87
Feb. 15	38.70	40.16	41.69	43.29	46.47	47.79	47.94	48.85	50.70	51.04	53.05	53.24
Mar. 15	44.70	49.79	44.87	47.39	46.80	47.72	47.64	48.19	49.50	49.86	51.36	51.60
April 15	54.28	56.49	51.59	51.73	50.15	49.99	50.13	49.91	50.60	50.39	51.48	51.30
May 15	64.89	68.95	60.05	60.74	55.63	53.40	54.76	53.88	53.71	52.84	53.36	52.70
June 15	73.66	84.36	67.98	72.79	61.77	62.90	60.27	60.93	57.98	57.97	56.51	56.21
July 15	78.27	84.51	73.26	76.86	66.91	68.09	65.20	65.87	62.29	62.26	60.08	59.69
Aug. 15	77.46	79.97	74.47	75.48	69.69	70.16	68.22	68.50	65.46	65.43	63.11	62.87
Sept. 15	71.46	72.69	71.29	71.39	69.36	69.68	68.52	68.96	66.66	67.04	64.80	64.88
Oct. 15	61.88	55.42	64.57	61.87	66.01	66.26	66.03	66.37	65.56	66.16	64.68	65.11
Nov. 15	51.27	46.04	56.11	53.27	60.53	60.11	61.40	61.07	62.45	62.46	62.80	63.18
Dec. 15	42.50	39.04	48.18	45.70	54.39	53.65	55.89	55.38	58.18	58.07	59.65	59.75

*Similar tables were made for the other four years, but are not included in this report.

The temperature curves, shown in Figures 7-9, for May and November cross the mean temperature axis, 57.75° F, at 2 ft. and 30 ft. Therefore, the half wave length and wave-length are 28 ft. and 56 ft. respectively. Similarly, the temperature curves for August and February cross the mean temperature axis at depths of 16 ft. and 44 ft. respectively, showing that the half wave-length and wave-length for these months are also 28 ft. and 56 ft. respectively.

Conclusions and Remarks

Soil temperatures have been measured and recorded, at two-hour intervals, from 1952 to 1956 inclusive. From the measured or observed data empirical equations were developed for calculating soil temperatures for a specified time and depth for each year and also for a five year norm.

The variation of soil temperatures with the time are presented graphically for different depths. From these graphs it can be seen readily the temperature amplitudes decrease with depth, and that maxima and minima of temperature shift from left to right as the soil depth increases.

The calculated value of the thermal diffusivity of the soil, for all depths, is 0.0279 $ft^2\ hr^{-1}$ for the five year period.

From the graphs showing soil temperature versus depth, the wavelength of the temperature waves was found to be 56 ft. The temperature graphs for each month of the year converge, in a sinusoidal manner, to the mean soil temperature of 57.75° F at a depth of about 100 ft.

An empirical equation was developed for calculating the mean air temperature at Lexington for any specified time. The mean air temperature and mean surface soil temperatures are 56.55° F and 57.75° F for the five year norm.

The graphs in Fig. 6 show clearly the manner in which the air temperature and the surface soil temperature vary with the quantity of solar energy that is received at the earths surface.

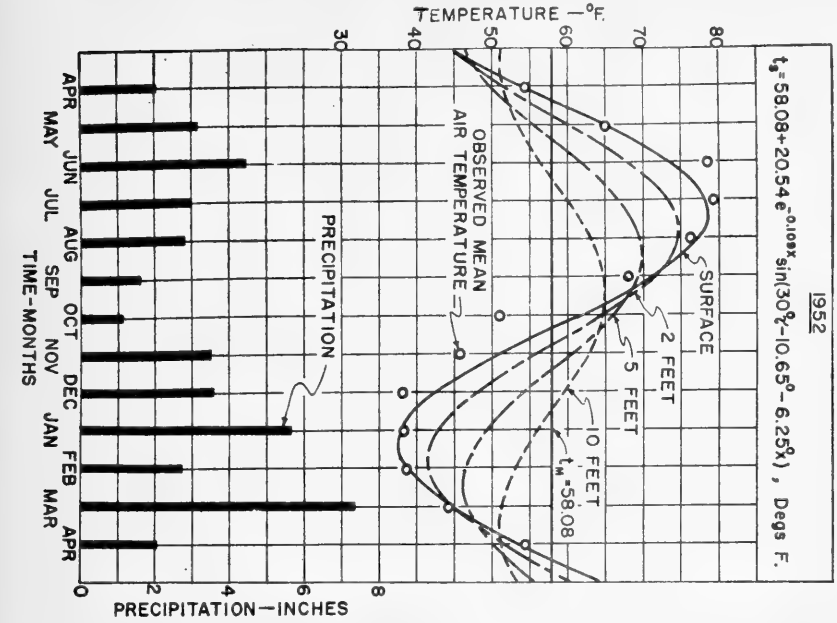

Fig. 1. Variation of soil temperature versus time at different depths. Soil temperatures were calculated by the use of the empirical equation developed for 1952.

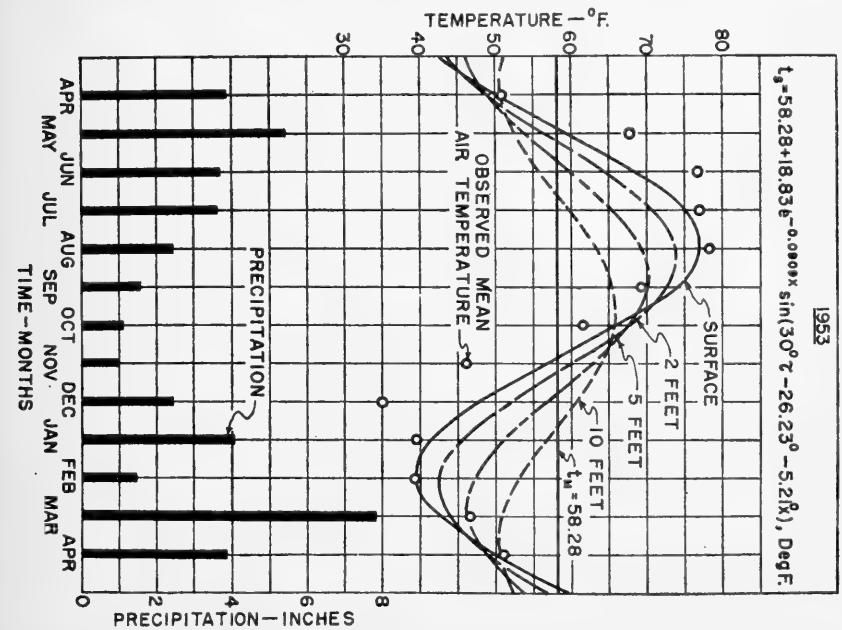

Fig. 2. Variation of soil temperature versus time at different depths. Soil temperatures were calculated by the use of the empirical equation developed for 1953.

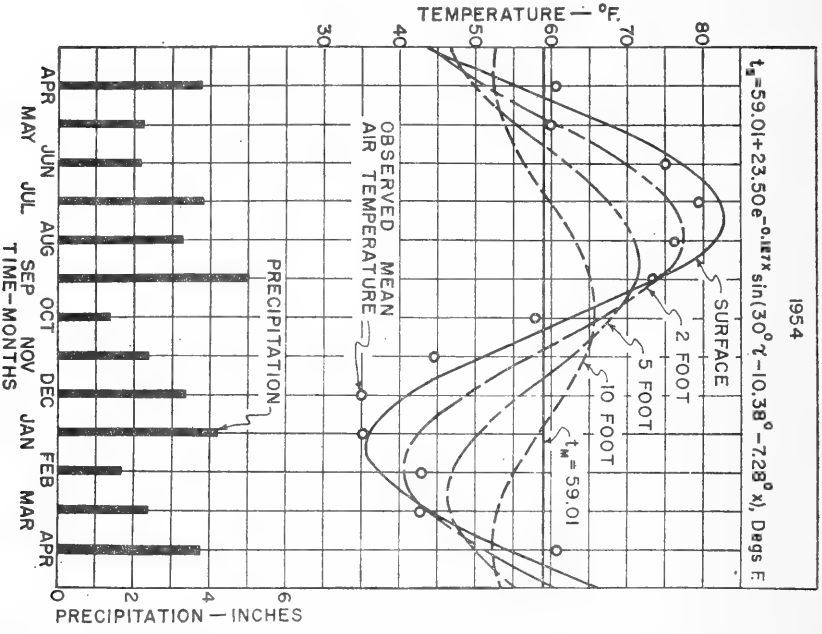

Fig. 3.— Variation of soil temperature versus time at different depths. Soil temperatures were calculated by the use of the empirical equation developed for 1954.

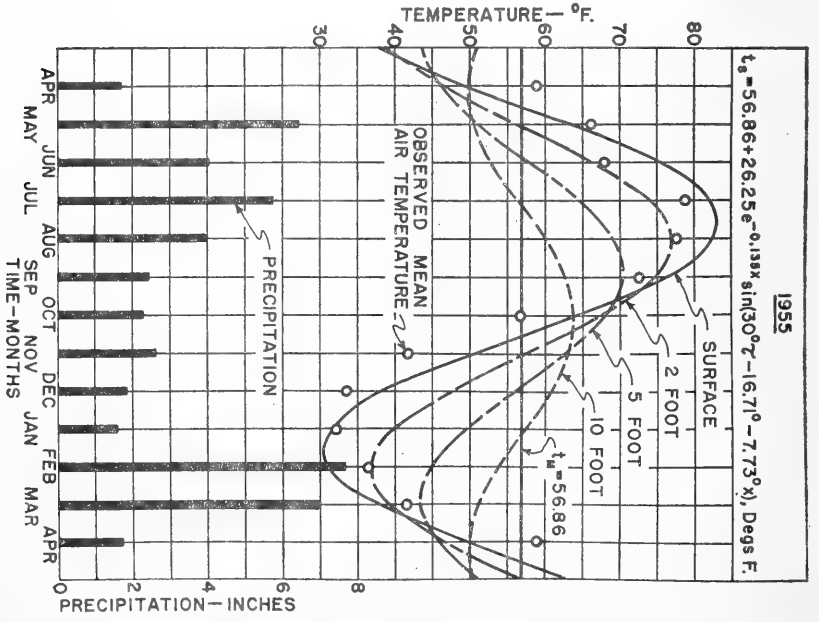

Fig. 4. Variation of soil temperature versus time at different depths. Soil temperatures were calculated by the use of the empirical equation developed for 1955.

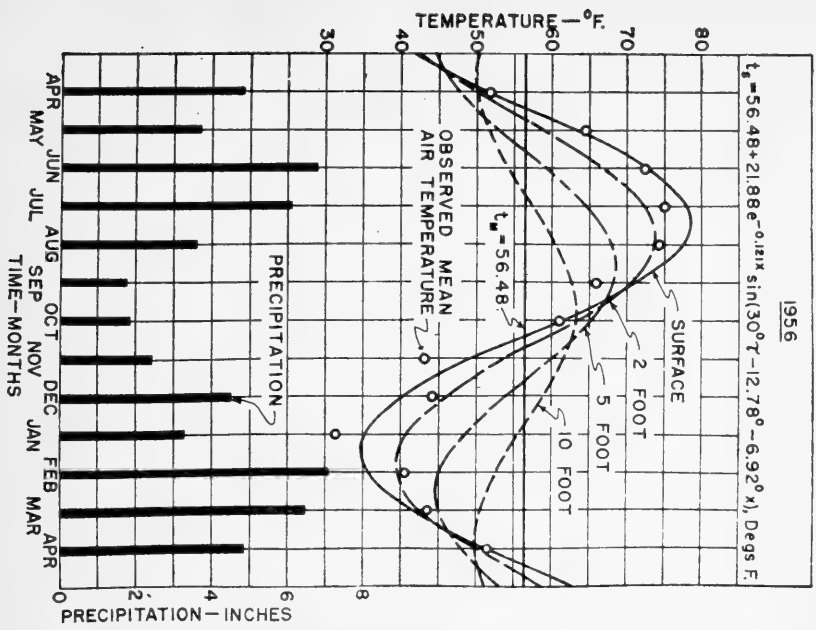

Fig. 5. Variation of soil temperature versus time at different depths. Soil temperatures were calculated by the use of the empirical equation developed for 1956.

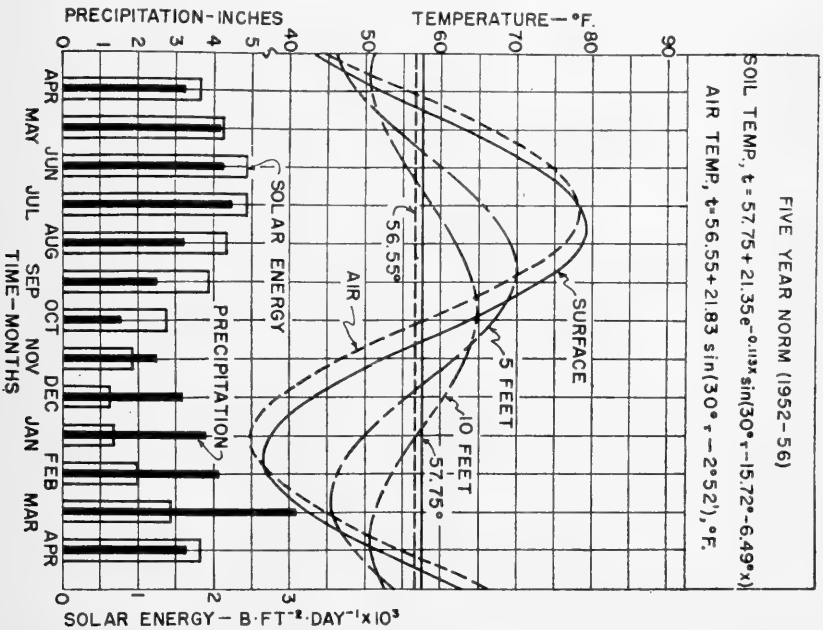

Fig. 6. Variation of soil temperature and mean air temperature versus time at different depths. Soil temperatures were calculated from the empirical equations developed for *the five year norm*. Similarly, mean air temperatures were calculated from the empirical equation developed for *the five year norm*. The mean soil temperature and mean air temperature for *the norm* are 57.75° F and 56.55° F.

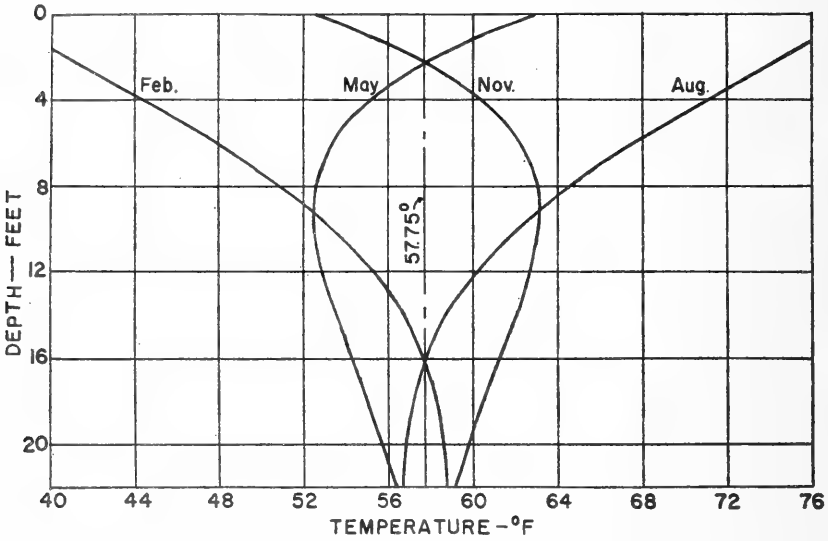

Fig. 7. Variation of soil temperature versus depth for *the five year norm* for 1952-1956. Rrange, from the surface to a depth of 22 ft.

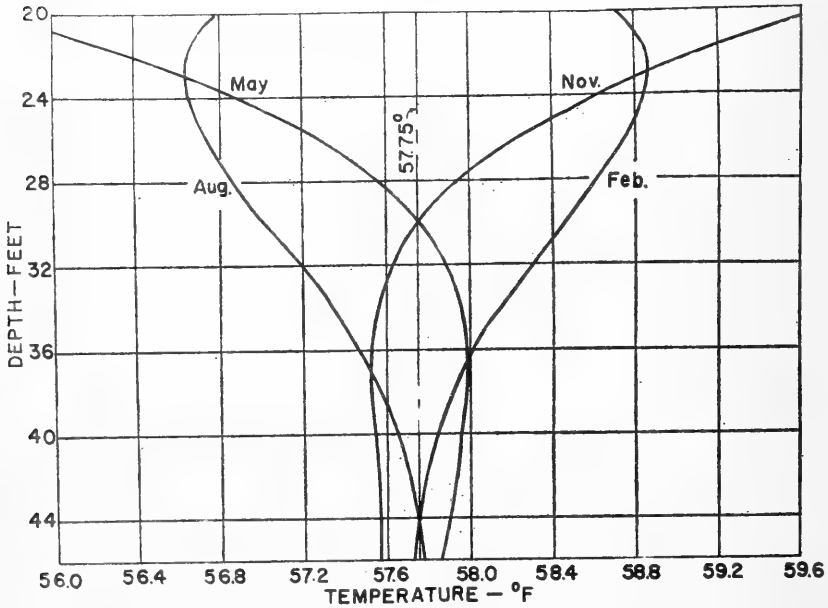

Fig. 8. Variation of soil temperature versus depth for *the five year norm* for 1952-1956. Range, from 20 ft. to a depth of 46 ft.

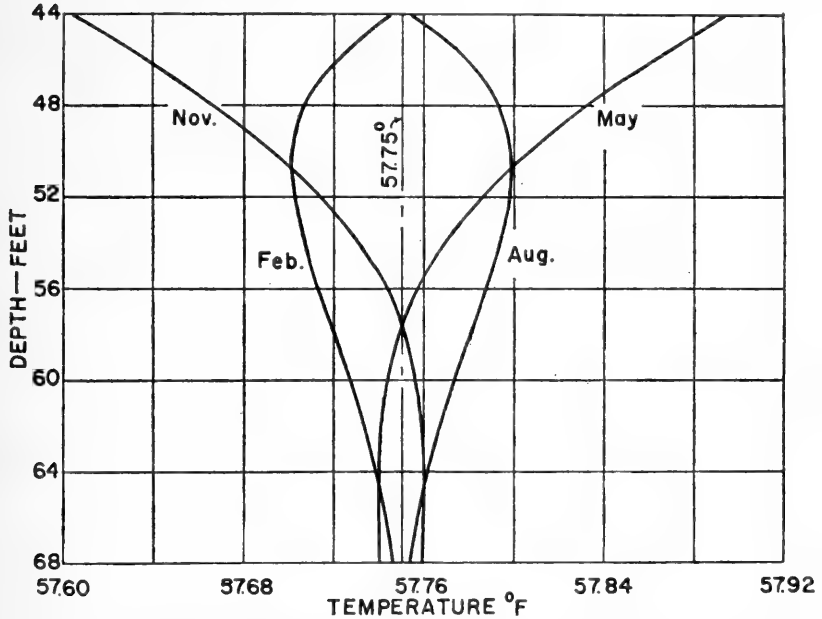

Fig. 9. Variation of soil temperature versus depth for *the five year norm* for 1952-1956. Range, from 44 ft. to a depth of 68 ft.

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CYCLIC ENTRY-EXIT FOR SUBROUTINES

J. C. EAVES and T. J. PIGNANI
Department of Mathematics and Astronomy
University of Kentucky, Lexington, Ky.

Introduction

The purpose of this paper is to call attention to the Cyclic Entry-Exit Method for subroutines used with high speed computers. We shall point out some of the advantages in using available subroutines. We shall outline the general principle followed in making a subroutine an integral part of one's own particular program. The merits of the Cyclic Entry-Exit Method will be discussed. For contrast with the usual treatment of this problem, the reader may wish to refer to the papers of Livesley (1957), McCracken (1957), and Wrubel (1959).

Whenever it is necessary to refer or make use of a computer instruction in this work we shall confine ourselves to the basic machine language, that is, the absolute codes, used for programming the IBM type 650 Magnetic Drum Data-Processing Machine.

Subroutines are actually prepackaged special purpose programs. Subroutines are becoming more in demand since the number of computer patrons has increased almost beyond reasonable expectation. Users represent virtually every field of study found on a university campus in addition to a variety of business and industrial activities. Inexperienced programmers, as well as the experts, have brought about a crutial demand for effective, efficient subroutines. Justification for the use of existing subroutines seems to be well founded in the following advantages:

1. *Time saving.* By avoiding duplication of program writing time a better utilization of programmer efforts is achieved.

2. *Better program.* A subroutine which has been carefully worked out and used is likely to be more nearly optimized than the usual program given its first ru.n This saves computer time.

3. *Debugged.* Subroutines available for use have been run and checked. The programmer may save considerable debugging time.

4. *Acceptability.* Most subroutines are supplied with established computational limitations and the user knows, through the error analysis studies of this particular subroutine, the acceptability and goodness of computed results.

Subroutine Entry-Exit Principle

A subroutine may be a correction routine needed for the correction of a program already underway or it may be a routine which causes the computer to perform a supplementary computation. In using a subroutine one attempts to make the subroutine an integral part of the main program. Thus the computer uses instructions from the main program until such time as those instructions contained in the subroutine are needed. The main program instruction just prior to entry into the subroutine must contain three items of information; namely, the operation to be carried out just prior to the use of the subroutine, the cell location affected by this operation, and the location of the first instruction of the subroutine. The final instruction of the subroutine usually directs the computer to leave the subroutine. The instruction address of this last subroutine instruction usually gives the cell location of the desired main program instruction to be executed immediately following completion of the subroutine.

The Cyclic Entry-Exit Method

For purposes of illustration we shall assume that our main program is to be stored in cells 0200 through 0499. We shall assume that the subroutine to be used is punched to be stored in cells 1800 through 1847. Furthermore, we shall assume that this subroutine is to replace instructions located in cells 0400 through 0478. The Cyclic Entry-Exit Method then requires the following modifications of instructions.

1. Replace the main program instruction xx yyyy 0400 of cell 0399 with the instruction xx yyyy 1800. This directs the computer to cell 1800 for its next instruction after the completion of operation xx.

2. The first instruction of the subroutine, located in cell 1800, is 69 0479 1801 which causes the computer to load the distributor with the instruction located in cell 0479. It should be noted that this is the first *main program instruction* to be used following the completion of the subroutine.

3. The second instruction of the subroutine is 24 1800 1802. This causes the computer to place the instruction, formerly in cell 0479, which is to be used immediately following completion of the subroutine, in the first cell used for the subroutine. The computer is then directed to cell 1802 where it obtains the first computational instruction of the subroutine. The computer procedes through the subroutine computations in the prescribed manner until it encounters the last instruction of the subroutine (which may not be in cell 1847 due to optimization).

4. The last instruction of the subroutine, written at the time the subroutine is prepared, directs the computer to get its next instruction from cell 1800. Thus the computer actually returns to the beginning of the subroutine only to find that the first instruction of the subroutine has been replaced by the desired instruction of the main program. This exit instruction is of the form xx yyyy 1800.

It should be noted that the insertion of a set of instructions is achieved by exactly the same procedure used for the replacement of a set of instructions. One merely has the first instruction of the subroutine direct the computer to the desired instruction to be performed immediately following the execution of the subroutine. Using the above illustration the first instruction of the subroutine would be xx yyyy 0400 in case we wish to insert the subroutine between the main program instructions carried in cells 0399 and 0400.

Generalized Use of Cyclic-Entry-Exit Method

Multiple use of the Cyclic-Entry-Exit Method for the insertion of several subroutines and the replacement of parts of the original program is demonstrated by the brief program below. In this skeleton program presented, we insert the subroutine in three places and furthermore the subroutine *replaces* those instructions in cells 0400 through 0478, of the program used in the former section.

Main Program		Revisions	
Cell	Instruction	Replacement Instruction	
0200			
. . .			
0257	xx yyyy 0258	xx yyyy 0400	
0258			
. . .			
0290	xx yyyy 0291	xx yyyy 0401	
1			
. .			
0350	xx yyyy 0351	xx yyyy 0402	
0351			
. . .			
0399	xx yyyy 0400	xx yyyy 0403	
0400	xx yyyy 0401	69 0258 1801	
0401	xx yyyy 0402	69 0291 1801	
0402	xx yyyy 0403	69 0351 1801	
0403	xx yyyy 0404	69 0479 1801	
0404		Delete	Replaced
. . .		. . .	by
0478		Delete	Subroutine
0479			
. . .			
0499			

Cell	Subroutine Instruction
1800	00 0000 0000, exit cell to be used as needed
1801	24 1800 1802
1802	First instruction of subroutine
. . .	
1847	xx yyyy 1800

A study of the above revised program shows that each time the program refers to the subroutine the operation to follow subroutine activity is stored in cell 1800. Also, part of that bank of cells deleted from the program is utilized for subroutine entry.

The insertion of several different subroutines is made by a very similar adjustment in the program.

Advantages of the Cyclic Entry-Exit Method

1. The replacement and insertion of instructions are carried out in the same way.

2. The programmer need not concern himself with the whereabouts of the last instruction of the subroutine since the exit is made through the entry cell.

3. Cyclic Entry-Exit Method requires only one alteration of the subroutine deck whereas other subroutine entry-exit techniques require the alteration of two or more of the subroutine instructions.

4. This method requires the use of only two extra operations and two extra cells of storage in the subroutine whereas many modified entry-exit programs make additional demands on storage and operation time. Especially is this true with those methods requiring accumulative additive features or instruction modification.

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THE SALTING EFFECT OF SODIUM CHLORIDE ON THE EXTRACTION OF ERBIUM ACETYLACETONATE AND 8-QUINOLINOL

Y. G. ISHIDA, J. F. STEINBACH and W. F. WAGNER
Department of Chemistry, University of Kentucky, Lexington, Kentucky

The use of salting agents has proved to be very effective in the solvent extraction of some metal salts, such as, the nitrates by tributylphosphate (Hesford and McKay, 1958), uranyl nitrate (Furman, Mundy, and Morrison), thorium nitrate (Bock and Bock, 1950), and ferric chloride (Morrison, 1950) by ether. Morrison and Freiser (1957) have summarized the effect of salting agents on the extraction of inorganic salt systems. Diamond (1957) has derived general equations for the solvent extraction of inorganic compounds and studied the effects of salting agents on the extraction of indium (III) chloride from aqueous hydrochloric acid by various organic solvents (Diamond, 1959). Very little work on the effect of salting agents on the extraction of chelates has been reported. Recent studies (Brown, Steinbach, and Wagner, 1960), on the solvent extraction of rare earth acetylacetonates by acetylacetone led to this study of the effect of salting agents on the system.

In addition, the extraction of 8-quinolinol (oxine) in a water-chloroform system was studied to compare the effect of salting agents on the neutral oxine, oxinate ion, and oxinium ion at different acidities. Lacroix (1947) has studied the properties and extraction of oxine by chloroform from aqueous solutions as a function of pH from 0 to 14. From potentiometric titration curves he showed that the oxinium ion (protonated oxine) exists in strongly acidic solutions, the neutral oxine is formed almost exclusively in the pH range of 6 to 9 and the oxinate ion is formed in more basic solutions. Extraction data showed an increase in extraction from 0.59% at a pH of 0 to quantitative extraction in the range of 5 to 6, then a decrease to 5% at a pH of 14.

Apparatus and Materials

A Beckman Model DK-2 recording spectrophotometer was used for all absorption spectra. A Beckman Model G pH meter was used for all pH measurements. Eastman 8-quinolinol was recrystallized twice from alcohol-water solution to give a product that melted at 74-75°. Acetylacetone obtained commercially was washed once with 10% ammonia solution, twice with water, and distilled; the fraction boiling between 135-138° was used. Erbium acetylacetonate was pre-

pared by the method of Stites, McCarty, and Quill (1948) and was recrystallized twice from 95% ethanol. All other chemicals met A.C.S. specifications for reagent grade.

Experimental

Solubility of Acetylacetone in aqueous solutions of potassium chloride and sodium chloride. Solutions containing varying amounts of the salts were prepared by dissolving the salt in water saturated with acetylacetone in 25-ml. volumetric flasks. The solutions were shaken and permitted to stand overnight at 25° and the excess acetylacetone which separated was removed. The concentration of acetylacetone in the solution was determined spectrophotometrically as iron acetylacetonate (Steinbach, 1953). One ml. of the solution was added to a 25-ml. flask containing 5 ml. of a solution of ferric sulfate (20 mg./ml.) and 10 ml. of a sulfuric acid-sodium sulfate buffer (pH = 0.5) and diluted to volume. The absorbance minimum of iron acetylacetonate at 700 mμ was used to plot a working curve for the concentration of acetylacetone. Alternatively, a 1:50 dilution of the sample was prepared and the absorbance of one to five ml. of the diluted sample was used to determine the concentration of the acetylacetone from a working curve prepared at the maximum absorbance of iron acetylacetone at 482 mμ.

Distribution of erbium acetylacetonate between acetylacetone and aqueous solutions of sodium chloride. Ten ml. of a solution of erbium acetylacetonate in water-saturated acetylacetone was shaken with 10 ml. of the acetylacetone-saturated water containing the salting agent. The phases were allowed to come to equilibrium overnight in a 25° bath. The erbium present in the organic phase was determined spectrophotometrically by measuring the absorbance of erbium acetylacetone at 378 mμ. The erbium present in the aqueous phase was determined spectrophotometrically by the arsenazo method of Fritz, Richard, and Lane (1958). Volumetrically the erbium in the aqueous phase was determined by adding an excess of standard 10^{-3} M EDTA and back titrating with standard 10^{-3} M zinc solution using PAN indicator.

Distribution of oxine between chloroform and water. Ten ml. of 0.1 M oxine in chloroform was shaken for an hour with 10 ml. of the solution of sodium chloride in water and placed in a bath at 25° for 24 hours to reach equilibrium. The concentration of oxine in the aqueous phase was determined by acidifying the solution to a pH of 1 and measuring the absorbance at 251 mμ. The concentration of oxine in the organic phase was obtained by difference.

Results and Discussion

Solubility of Acetylacetone. Data for the solubility of acetylacetone in aqueous solutions of sodium chloride and potassium chloride at 25° are shown in Table I and Figure 1. The solubility of acetyl-

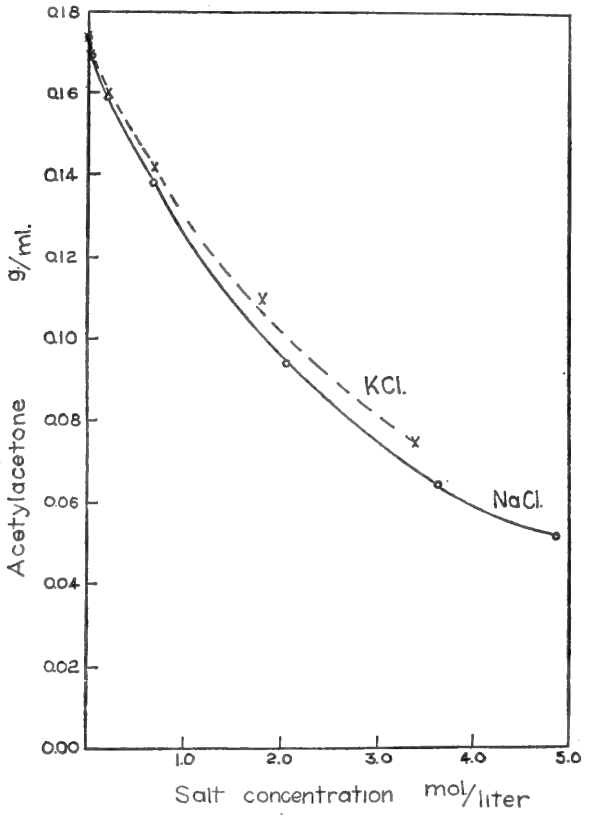

Fig. 1. Solubility of Acetylacetone in solutions of NaCl and KCl at 25°.

Table I.— Solubility of Acetylacttone in Solutions of NaCl and KCl at 25°

NaCl			KCl		
NaCl Mol./1.	pH	$C_5H_8O_2$ g./ml	KCl mol./1.	pH	$C_5H_8O_2$ g./ml
0.000	4.68	0.173	0.000	4.68	0.173
0.034	4.67	0.169	0.032	4.65	0.169
0.206	4.60	0.159	0.215	4.63	0.160
0.684	4.49	0.138	0.698	4.61	0.142
2.05	4.34	0.094	1.81	4.59	0.110
3.64	4.25	0.065	3.38	4.57	0.075
4.87	4.23	0.052			

acetone in solutions of sodium chloride is slightly lower than in solutions of potassium chloride, probably due to the lower activity of the water containing the more highly hydrated sodium ion.

In the spectrophotometric determination of acetylacetone it was found that the absorbance minimum for iron acetylacetone at 700 mμ shifts to higher wave lengths with an increase in concentration and Beer's Law is not obeyed. Consequently, the absorbance maximum for iron acetylacetonate at 482 mμ where Beer's Law is followed was used for most analyses.

Distribution of erbium acetylacetonate. The data for the extraction of erbium acetylacetonate from aqueous solutions of 0.1 M and 1.0 M sodium chloride as a function of pH are shown in Table II and Figure 2. The extraction curve in 0.1 M NaCl was practically identical to that without any salt present, while in 1.0 NaCl the curve was shifted

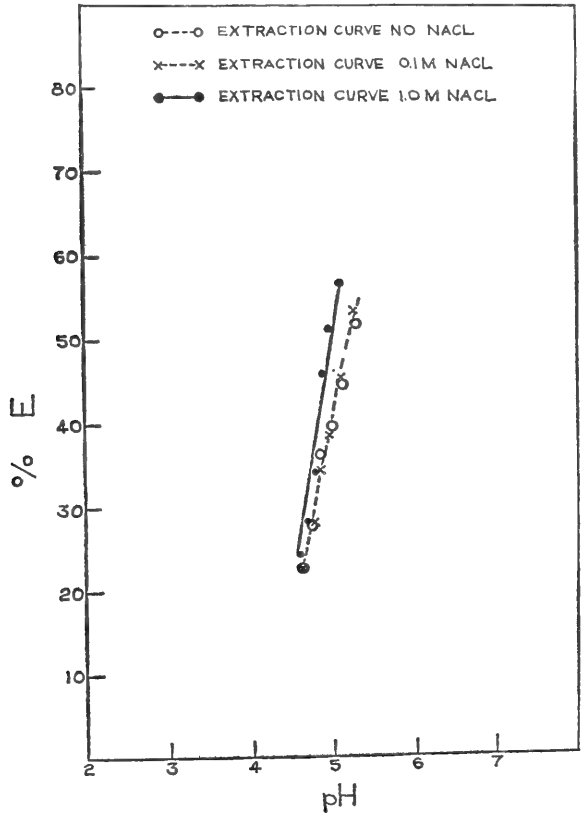

Fig. 2. Extraction of Erbium Acetylacetonate as a function of pH.

Table II.— Extraction of 5.48 x 10^{-3}M Eribium Acetylacetonate as a Function of pH from 0.1M and 1M NaCl at 25°

Water		0.1M NaCl		1.0M NaCl	
pH	%E	pH	%E	pH	%E
4.62	22.6	4.61	22.6	4.61	24.3
4.75	27.9	4.77	28.3	4.69	28.5
4.85	36.4	4.85	34.7	4.79	34.3
4.97	39.8	4.96	38.9	4.89	46.0
5.14	44.9	5.11	45.6	4.99	51.4
5.30	52.0	5.25	52.7	5.09	57.0
				5.40	Pptd.

to lower pH values by about 0.10 units at a pH of 4.61 and by about 0.25 units at a pH of 5.30. A decrease in solubility of acetylacetone in the aqueous phase with increasing concentration of sodium chloride should cause the extraction curves to shift to higher pH values. The shift may be calculated from the equation

$$D = \frac{K_f p_c K_i^3 [HR]^3}{[H^+]^3}$$

where D is the distribution coefficient, K_f is the formation constant of the chelate, p_c is the partition coefficient of the chelate, K_i is the dissociation constant of the acetylacetone, and [HR] is the concentration of acetylacetone in the aqueous phase. In 0.1 NaCl, with other factors constant, the change in concentration of acetylacetone would raise the pH of extraction approximately 0.02 units between a pH of 4.61 and 5.30; in 1.0 M NaCl the shift would be +0.12 units at a pH of 4.61 and +0.14 units at a pH of 5.30. Since the experimental curve showed little if any shift in 0.1 M NaCl it is apparent that 0.1 M NaCl had very little effect on the distribution coefficient. However, in 1.0 M NaCl the experimental curve was shifted to lower pH values. An increase in ionic strength causes a decrease in the formation constants of chelates and an increase in the dissociation constants of weak acids. The presence of sodium chloride in the water makes that phase much less attractive for the chelate, increasing the partition coefficient in favor of the organic phase.

Thus, in 1.0 M NaCl the changes in the partition coefficient and the dissociation constant of acetylacetone cause a shift to lower pH values which more than compensates to the shift to higher values by the change in the formation constant of the chelate and decreased solubility of acetylacetone in the aqueous phase.

Because buffered solutions are required in counter-current separations the effect of buffers on the extraction of erbium acetylacetonate was investigated. The addition of a sodium acetate-acetic acid buffer

lowered the per cent of erbium extracted at a given pH. It has been suggested (Brown, 1959) that this shift of the extraction curve to higher pH values is due to the decrease in reagent concentration in the aqueous phase by increasing the ionic strength of the solution. However, the addition of 0.05 M NaCl to the buffered solution raised the per cent of erbium extracted. The shift of the extraction curves to higher pH values in buffered solutions is probably caused mainly by the association of acetate ion with some of the erbium to reduce its extraction into the organic phase. When potassium acid phthalate-sodium hydroxide buffer was substituted for the acetate buffer at the same pH and ionic strength, the per cent erbium extracted at a pH of 5.1 was 32% as compared to 47% for the acetate buffer, and 50% for an unbuffered solution. The lower extraction in the phthalate buffer probably is caused by the greater extent of complex formation between the phthalate ion and erbium. The addition of 0.05 M NaCl to the phthalate buffered system improved the extraction.

Distribution of oxine. Data for the extraction of oxine by chloroform from acidic, approximately neutral, and basic solutions of sodium chloride are shown in Table III. The addition of sodium chloride had

Table III.— Extraction of 10^{-2} M Oxine by Chloroform From Acidic, Neutral, and Basic Solutions of Sodium Chloride

pH	NaCl, m/1.	%E
2.5	0.00	20.0
2.5	0.05	31.3
2.6	0.50	35.0
2.6	1.00	39.0
2.5	2.70	61.9
6.5	0.00	99.5
6.7	0.05	99.6
6.6	0.50	99.6
6.8	1.00	99.6
6.9	2.70	99.7
9.8	0.00	62.2
9.8	0.05	60.1
10.2	0.50	61.9
10.6	1.00	62.6
10.8	2.70	65.4

the greatest effect on the extraction of oxine from an acidic solution where the oxinium ion predominates; the per cent extracted increases from 30% to 60% upon the addition of 2.7 M NaCl. In the pH range 6.5 to 6.9 where the oxine exists essentially as the neutral molecule, the addition of sodium chloride has very little effect since the oxine is almost quantitatively extracted in this range. In the basic solutions

the addition of sodium chloride in concentrations of 0.05 to 0.5 caused a small decrease in extraction of the oxine which, however, increased with an increased in concentration of sodium chloride.

The distribution of oxine may be calculated from the equation (11):

$$D = \frac{K_D}{\frac{[H^+]}{K_1} + 1 + \frac{K_2}{[H^+]}}$$

where D is the distribution ratio, K_D is the partition coefficient of the oxine, K_1 is the dissociation constant of the oxinium ion, $H_2Ox^+ = H^+ + HOx$ and K_2 is the dissociation constant of oxine $HOx = H^+ + Ox^-$. In acidic solutions where the H_2Ox^+ ion predominates, the third term in the denominator is negligible and the distribution is dependent on K_1. An increase in ionic strength increases the value of K_1 causing an increase in D which, with an increase in K_D by the salting effect of the sodium chloride, causes a marked increase in the extraction of oxine. In basic solutions where the oxinate ion predominates, the first term in the denominator is negligible and the distribution is dependent on K_2. An increase in ionic strength increases the value of K_2, causing a decrease in D at lower concentrations of sodium chloride. As the concentration of sodium chloride is increased the salting effect, by increasing K_D, more than compensates for the increased K_2, and the extraction of oxine increases.

Summary

The solubility of acetylacetone in solutions of sodium chloride and potassium chloride was determined.

Extraction of erbium acetylacetonate by acetylacetone from the aqueous phase was shifted to lower pH values by the addition of sodium chloride. The increases in the partition coefficient of the chelate and dissociation constant of acetylacetone by increasing ionic strength more than compensates for the shift to higher pH values by the decrease in concentration of acetylacetone and decrease in formation constant of the chelate.

The addition of sodium chloride improves the extraction of oxine from water by chloroform in acidic solutions, has a small effect in basic solution, and has very little effect in neutral solutions. The influence of ionic strength on the dissociation constants of oxine and on the partition coefficient was used to explain the results.

Acknowledgement

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A NEW NORTH AMERICAN LEAFHOPPER PREVIOUSLY CONFUSED WITH *TYPHLOCYBA ANDROMACHE* McATEE (HOMOPTERA CICADELLIDAE)

PAUL J. CHRISTIAN
Department of Biology, University of Louisville, Louisville, Kentucky

Contribution No. 30 (New Series) from the Department of Biology, University of Louisville.

Introduction

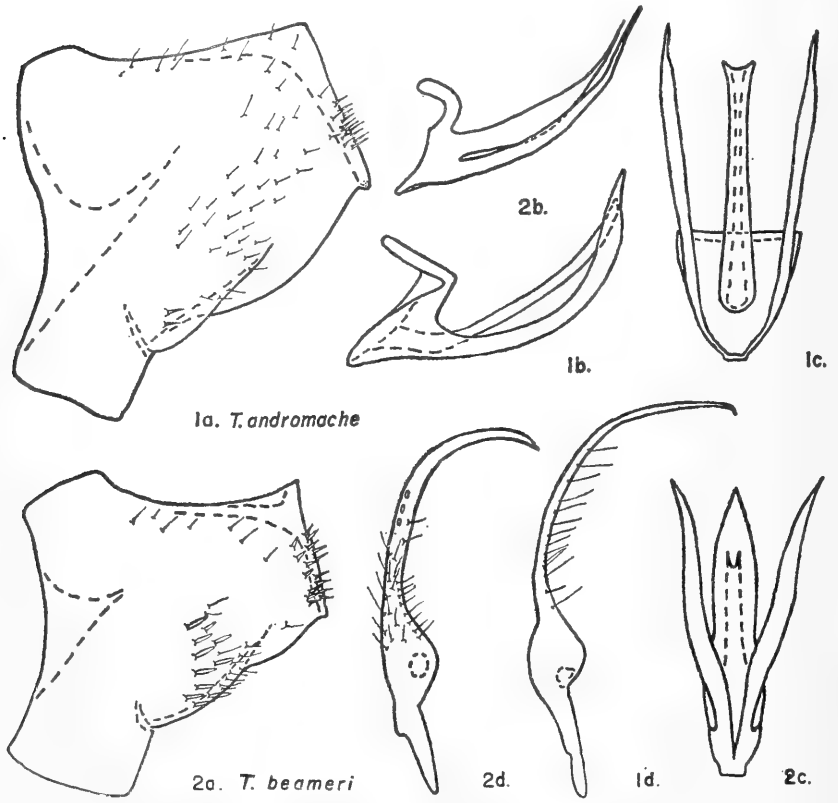
In 1926 W. L. McAtee revised the North American species of the genus *Typhlocyba* and described in this revision a new species which he named *Typhlocyba andromache*, from one male specimen collected in Salem, New York, June 27, 1924. In 1942 J. T. Medler redescribed this species and recorded it from Minnesota specimens.

When McAtee described the species his method of preserving the cleared dissection was to fasten it to the same point to which the rest of the insect was glued, with a mixture of glycerin and shellac (McAtee 1926, p. 3). At the time he indicated uncertainty as to how suitable this method of preservation would be. The author found on reexamining McAtee types that this material was difficult to remove. In working on the type of *T. andromache* it was possible to clean the pygofer sufficiently to draw the posterior margin, but the aedeagus being much smaller and more delicate could not be cleaned suitably for observation. The specimens Medler used were in good condition, and since no other specimens of this species could be found in North American collections the author used one of these in his description of this species in his revision of the genus *Typhlocyba* (Christian, 1953).

The posterior margin of the pygofer of the type was not exactly like that of Medler's specimens, but the degree of difference was such as might be attributed to individual variability. The aedeagus of Medler's specimens also differed from the description of the aedeagus of the type which was described as being bifid at the apex, although Medler had described his specimens as being bifid, because the sclerotized portion of the shaft appeared bifid and the transparent portion was overlooked. Since McAtee had overlooked the transparent portion of the aedeagus in other species of *Typhlocyba (rubriocellata, niobe)* the author assumed that he had done the same in this case and that Medler's specimens were *Typhlocyba andromache*.

In the spring of 1957 the author collected from *Carpinus* a large series of specimens which appeared to be an undescribed species of *Typhlocyba* resembling *T. andromache* in the author's revision but differing in the shape of the aedeagus and posterior dorsal angle of the pygofer. On comparing the pygofer with a drawing of the type of *T. andromache* and the original description of the species it was concluded that these were specimens of *T. andromache* and what had been described as *andromache* was an unnamed species. The following descriptions of these two species should help workers in identifying them.

I wish to express my appreciation to Dr. G. W. Byers for the loan of specimens from the Snow Entomological Museum of the University of Kansas, and to Dr. F. F. Cook for loan of specimens from the University of Minnesota collection.



Figs. 1-2.— Male genitalia of *Typhlocyba andromache* and *T. beameri*. a. Left side of pygofer. b. Left side of aedeagus. c. Posterior aspect of aedeagus. d. Ventral aspect of right style.

Typhlocyba beameri n. sp.
(Figs. 2a,b,c,d.)

Typhlocyba andromache, Medler, 1942, Minnesota Agr. Exp. Sta. Tech. Bull., 155:144-5. (in error)

Typhlocyba andromache, Christian, 1953, Bull. Univ. Kansas Sci. Bull., 35(II,9):1176, pl. 83, fig. 4a,b,c,d. (in error)

Resembling *Typhlocyba* andromache McAtee in shape of pygofer but with dorsal posterior angle acute forming less than a right angle, and with apex of aedeagal shaft acute as in *Typhlocyba surcula* DeLong and Johnson.

Length.—3.0-3.25 mm.

Color.—Dorsum pale yellowish-white; fore wings subhyaline to cross-veins, apical cells hyaline, slightly fumose, without distinctive markings.

Genitalia.—Male pygofer: in lateral aspect with posterior margin nearly straight, dorsal angle acute, slightly less than a right angle, ventral angle slightly more than a right angle and forming a small ventrally-directed hook. Aedeagus: with atril processes broad, elongate, exceeding shaft in length, arising from base close to shaft, gradually diverging laterodorsad from base, slightly sinuate, reduced to acute apices on outer fourth; shaft arising from base slightly above bases of processes, laterally broadened, margins foliaceous, broadest at gonopore, nearly transparent and extending beyond gonopore as a thin plate with acute apex. Styles: broadly tapering to near apex, abruptly reduced to sharp apices.

Types.—Holotype male and five paratype males, Itasca County, Minnesota, July 26, 1939, J. T. Medler, in the Snow Entomological Museum of the University of Kansas; two paratype males, July 26, 1939, and one paratype male July 28, 1939, Itasca County, Minnesota, J. T. Medler, in the collection of the University of Minnesota; one male paratype, Sturgeon Bay, Wisconsin, July 29, 1951, D. A. Dever, in the collection of the author.

Typhlocyba andromache McAtee
(Figs. 1a,b,c,d.)

Typhlocyba andromache McAtee, 1926, Proc. U. S. Nat. Mus., 68(18): 32., fig. 67.

Resembling *Typhlocyba beameri* in the shape of the posterior margin of the pygofer, but differing in having the dorsal posterior

angle slightly rounded, forming not less than a right angle, and having apex of aedeagal shaft bifid.

Length.—3.5 mm.

Color.—Head, pronotum and scutellum white to pale yellow, tegmina lemon yellow, subhyaline to cross veins, apices hyaline, slightly fumose, without distinctive markings.

Genitalia.—Male pygofer: in lateral aspect, with posterior margin nearly straight, dorsal angle slightly rounded, forming a right angle, ventral angle slightly more than a right angle and forming a small ventrally-directed hook. Aedeagus: with atrial processes slender, slightly enlarged near apical third, gradually tapering to sharply acute apices, slightly diverging dorso-laterad from base, apices slightly sinuate in lateral aspect, exceeding shaft in length, distinctly separate from shaft from base, shaft of nearly uniform width, gradually tapering to slightly inflated bifid apex, gonopore apical. Styles: slender, gradually tapering to needlelike apices.

Material studied.—Holotype male, Salem, New York, June 27, 1924, E. D. Ball; a large series of male and female specimens, Louisville, Kentucky, May 1957, collected on *Carpinus* sp. by the author. A female specimen taken in copula with the male used in making the drawings of the male genitalia of this species in this paper, collected May 30, 1957, Louisville, Kentucky, here designated *Neallotype*, is deposited in the Snow Entomological Museum of the University of Kansas.

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STUDIES OF THE OVERWINTERING POTENTIAL OF CERTAIN DROSOPHILA SPECIES

WALLACE D. DAWSON
Present address: Dept. Zoology, Ohio State University

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Introduction

Many investigators, both in this country and abroad, have found that *Drosophila* populations tend to exhibit a characteristic seasonal population frequency cycle. Patterson (1943) in collections at the Aldrich farm near Austin, Texas, over a three year period showed that *D. melanogaster* reached a peak population in September, while *D. affinis-algonquin* frequencies were high during the cooler months of the year, but extremely low during the mid-summer months. *D. putrida* populations tended to vary with rainfall, being high during periods of high precipitation. Williams and Miller (1952) in Nebraska and Carpenter and Giordano (1955) in Tennessee demonstrated similar seasonal fluctuations. Mather (1956) showed high summer frequencies for *D. melanogaster* in Queensland, Australia, as did Takada (1957) in Japan.

The various possible causal factors of these seasonal changes have elicited interest from several investigators. Most attention has been given to climatological, nutritional and genetic factors. Patterson (1943), Speiss (1949), Levitan (1954), Jones (1958) and others found that high frequencies of *D. melanogaster* and *putrida* can be correlated with temperature and precipitation increases, respectively. Studies by Komatsu (1959) indicate that food selectivity is not a major factor in controlling the size of *Drosophila* populations. Dubinin and Tiniakov (1946), Dobzhansky (1956), Carson and Stalker (1949) and Levitan (1951) have studied seasonal changes in inversion frequencies of several species of *Drosophila,* but whether they are of any significance in the determination of population density has not been determined. The availability of suitable breeding sites, as suggested by Carson and Stalker (1951) and Carson, Knapp and Phaff (1956) may be a limiting factor.

The various seasonal studies have suggested that there may be differences in the ability of the various flies to survive the winter, which largely determine the subsequent behavior of the population during the remainder of the year. The high frequency of *D. affinis-*

algonquin in the spring and late autumn indicates that this fly may be better adapted to cooler temperatures than other native and domestic species. *D. affinis-algonquin* may survive the winter in greater numbers than other species and, therefore, have a greater initial reproducing population during the first warm days of spring. On the other hand, such species as *D. melanogaster,* which are rare in the spring but attain a high population in August and September, may not survive the winter in natural habitats, or else may survive in extremely low numbers, and thus may have to reestablish their populations annually from domestic situations, or, alternatively, require several months to attain sufficient numbers of reproducing flies to establish a peak population.

In this study two approaches to the overwintering problem were undertaken. First, field collections for adult *Drosophila* in natural wooded habitats were made during the winter, particularly during brief mild spells. Materials which might contain overwintering eggs, larvae or pupae were also collected in the field. Second, various species were directly tested in the laboratory under controlled conditions by exposure to low temperatures for given periods of time. Such investigations should provide information on the comparative tolerances of these species to cold, which could then be correlated with the seasonal population fluctuations observed during warmer periods of the year.

Materials and Methods

Collecting Methods. A wooded area seventeen miles southeast of Lexington, Kentucky, near the Kentucky River was selected as a favorable location for the winter collection of flies. The area was designated Dry Branch Field Station. This location is remote from any urban influences, with human habitation in the area being limited to two small farm tenant houses. Collecting was not done in the immediate vicinity of these dwellings. There are no considerable garbage disposals, orchards, gardens or other similar factors which might affect *Drosophila* populations in the area. Deciduous trees and red cedar, together with a wide variety of undergrowth compose the vegetative cover.

For collecting, a modification of the bottle method outlined by Dobzhansky (1936) was utilized. One-half pint milk bottles baited with a slant of banana-malt-agar mixture were inserted in the forks of trees and other suitable locations at a number of separate points within the area. After a week or ten days flies were collected by inserting a gauze covered cotton stopper in the neck of the bottle. The entrapped flies were returned to the laboratory for identification.

Collection records included number of flies of each species collected, climatological data and miscellaneous other information, including observations on the condition of the flies.

Collection of materials which could possibly contain overwintering eggs, larvae, or pupae consisted of selecting a variety of likely materials, such as decaying material from tree stumps, walnut hulls, fruits, etc., and placing these in a carton with a small amount of culture medium and holding them at optimum temperatures for two or three weeks, then observing whether adult *Drosophila* were present.

Techniques for Low Temperature Studies. *Drosphila* stocks of the species *affinis, robusta, melanogaster, immigrans, hydei, cardini* and *tripunctata* were maintained in culture for use in low temperature studies. All stocks except *hydei* and *cardini* were derived originally from wild flies taken in collections at Dry Branch during the summer of 1958. The *hydei* culture was obtained from domestic flies in the laboratory. The *cardini* stock was derived from several flies taken from a swamp near Orlando, Florida. Most of the low temperature experiments involved *affinis, robusta* and *melanogaster*, therefore, only these species were cultured extensively. Flies were all cultured on a medium of corn meal agar fortified with sugar and dried yeast with occasional modifications.

For many of the low temperature tests it was desirable to have flies of a known age range in order to standardize the experiments as much as possible and to minimize errors in the results due to natural death. Aged flies were obtained by clearing thriving culture bottles, in which adults were ecluding from the pupae in large numbers, of all adult flies. These bottles were then held separately for thirty-four hours and all adults which had emerged in the interval fell within the desired age range. These flies were lightly etherized and examined prior to placing in testing bottles. Flies which showed structural defects and which were very recently emerged were rejected. Flies were chosen randomly from the remainder keeping sex ratio approximately equal.

For the purpose of exposure to low temperature flies were placed into half-pint milk bottles which had been specially prepared. Each bottle had at the bottom a moist square of bibulous paper thoroughly innoculated with a yeast suspension upon which the flies could feed prior to testing. Any excess moisture was removed prior to placing the flies in the bottles. A dry elongated folded strip of bibulous paper was inserted along one side of the bottle. The bottle was positioned with this side down, and the flies while yet under etherization were placed upon this folded strip in the desired numbers. The bottles

were closed with a gauze covered cotton stopper. The flies were then permitted to revive in the bottle and fed for a period of two hours.

Prior to exposure a period of acclimatization at +7° C. (±1°) was allotted for a period of time, generally overnight.

For the low temperature experiments the freezer chest of a standard commercial eight cubic foot refrigerator was used. This equipment had certain limitations, the principal one of which was difficulty in maintaining an exact constant temperature, especially at the lower ranges used, thus the resultant data lists temperatures in ranges, for example "–5° C. range" is equivalent to –5° C. (±2°).

Following the acclimatization period flies in the testing bottles were placed in the freezer chest for the desired time. During this time occasional random readings were made from a thermometer in the chest to insure that the temperature did not vary from the desired range.

After a given period in the freezer the flies were removed and a four hour period at +7° C. was allotted for deacclimatization since rapid warming appeared to reduce survival. Following this the bottles were removed to room temperature and permitted to stand for one hour. The flies were then emptied into a 10 x 16 x 2 inch white enamel pan for checking.

Flies were examined and categorized into four rather well defined major groups based upon the degree of damage to the fly:

Complete survival: Flies which behaved normally and displayed regular flight when stimulated. The criteria used for defining this category was the ability of the insect to fly from the floor of the pan with a sustained flight.

Crippled: Flies which were capable of any degree of walking, but which were unable to maintain a sustained flight sufficient to escape from the pan.

Stunned: Flies which were not capable of locomotion, but displayed movements and twitchings when observed closely with a binocular microscope.

Dead: Flies which displayed no movements or other signs of life when observed closely under a binocular scope.

Since at least some of the flies in the crippled category as well as those which completely survived exhibited reproductive capability following cold treatment, both of these categories were considered as survival. The stunned flies inevitably died within a few hours without any degree of recovery, and therefore, these together with the dead were considered as non-survivals.

Results

Overwinter Collections. In the course of the two year overwinter studies 1193 *Drosophila* flies representing ten species were collected at the Dry Branch area. Of this number 308, representing six species, were taken during the critical months, December through March. The remainder of the flies were collected during the latter half of November and during the first half of April. A summary of collections is presented in Table I.

Table I

	1957 - 1958							1958 - 1959						
Month	Number of collections	affinis-alg.	putrida	robusta	tripunctata	other	total	Number of collections	affinis-alg.	putrida	robusta	tripunctata	other	total
Last half November	0						0	2	13	15	8	9	30	75
December	3	8				5	13	5	8	4	1	8	1	22
January	3	1					1	4	33	4		2		39
February	3						0	5	13	2				15
March	4	2	4				6	4	115	68	25	3	1	212
First half April	3	55	145	6	5	2	213	2	200	240	55	1		496
Total Dec.-Mar. only	13	11	4			5	20	18	169	78	26	13	2	288

Of the six species taken during the December-March period two, *D. transversa* and *nigromelanica*, were represented by single specimens taken during December 1958. The other species were *D. affinis-algonquin* (180 flies), *putrida* (82 flies), *robusta* (26 flies), and *tripunctata* (13 flies). Five flies, dried beyond recognition, were not identified. They were apparently either *affinis* or the dark form of *putrida*. Species which were not taken during the critical period, but which were collected in November and/or April were the cosmopolitan species *melanogaster, immigrans, hydei* and *busckii*. All of these occurred in numbers of fifteen or less.

The number of flies taken during the critical period of the two winters was disproportionate. In the winter 1957-58 only twenty flies were taken in thirteen collections from December through March.

During the same period of 1958-59 288 flies were taken in eighteen collections. The difference is probably due to the severity of the 1957-58 winter which was 3.8° F. colder per month than the mean average for Kentucky.

A correlation was shown to exist both winters between the number of live flies collected and the temperature at the time of collection. Live flies were seldom obtained at temperatures below 40° F. In one instance a live *D. putrida* was in a trap taken at 18° F. No other live flies were taken at temperatures below 34° F. Occasionally dead flies were found in the traps and these were tabulated in the totals. In the winter 1957-58 fifteen of the twenty flies taken during the December-March period were alive. In the same period of 1958-59 241 of the 288 flies taken were living.

During March and April 1958 twenty-eight flies of the *D. affinis-algonquin* sibling species were examined for sex. Twenty-one of these were females and six were males. In January through April 1959 sex ratio was determined in 334 *affinis-algonquin*. There were a total of 144 females and 190 males. Males outnumbered the females by approximately twenty-five per cent during each of the four months.

No significant correlation could be established between the number of flies or the relative abundance of any species obtained and precipitation or relative humidity.

Collection of various types of material which were incubated in the laboratory to discern whether they served as suitable media for overwintering *Drosophila* eggs, pupae or larvae did not prove fruitful, although more than two hundred samples were collected in the course of the two winters. Special attention was given to decaying fruits, bark around slime fluxes, fleshy fungi, and similar materials which might be likely hibernacula.

Direct Response Tests. A comprehensive series of experiments was conducted to determine the direct response of adult *Drosophila* after exposure to freezing and below freezing temperatures for various lengths of time. Including a period for feeding and acclimatization, all flies fell within an age range of ten to fifty-four hours from eclosion at the time they were placed into the freezer for testing. Relatively few of the flies were at the extremes of this age range.

In these experiments the species *D. affinis, robusta* and *melanogaster* were used. These species were selected primarily because their seasonal population cycles are well known and they can be readily maintained in the laboratory. These species also presented the opportunity to contrast two common native species with an abundant domestic species in a comparative temperature tolerance study.

In each experiment of this series, except one, ten flies of each of three species were used. Each experiment was repeated once. In one test a total of seventy flies were used.

Temperature ranges used were 0°, −5°, −10°, −15°, and −20° C. all ±2°. Time exposures selected were one, four, eight, twelve, eighteen, twenty-four, thirty-six, forty-eight and sixty hours. These times and temperatures were selected because they best demonstrated the differences in survival capabilities of the species used. At the 0° C. range it was not necessary to use the shorter time exposures, since all

Table II

Hours Exposure	Species	0°	-5°	-10°	-15°	-20°
1	affinis	-	100	100	100	10
	robusta	-	100	100	55	10
	melanogaster	-	100	95	55	10
4	affinis	-	100	100	25	0
	robusta	-	100	90	0	0
	melanogaster	-	100	30	0	0
8	affinis	-	100	100	0	0
	robusta	-	100	60	0	-
	melanogaster	-	90	5	0	-
12	affinis	-	95	90	0	-
	robusta	-	30	50	0	-
	melanogaster	-	0	5	0	-
18	affinis	100	99	85	0	-
	robusta	100	100	0	0	-
	melanogaster	100	0	0	0	-
24	affinis	-	90	10	0	-
	robusta	-	60	0	-	-
	melanogaster	-	5	0	-	-
36	affinis	-	95	0	-	-
	robusta	-	50	0	-	-
	melanogaster	-	0	0	-	-
48	affinis	100	85	-	-	-
	robusta	100	60	-	-	-
	melanogaster	40	0	-	-	-
60	affinis	90	90	-	-	-
	robusta	100	15	-	-	-
	melanogaster	5	0	-	-	-

species showed good survival at these levels. On the contrary at the lower temperature ranges, only short exposures were required since no flies survived beyond these limits. The results of this series of experiments are summarized in Table II.

When a lethal dosage of fifty per cent for each species, as nearly as it could be determined from the results, is plotted against temperature and time, the differential in survival at low temperature can be clearly demonstrated graphically (Fig. 1). *D. affinis* shows better

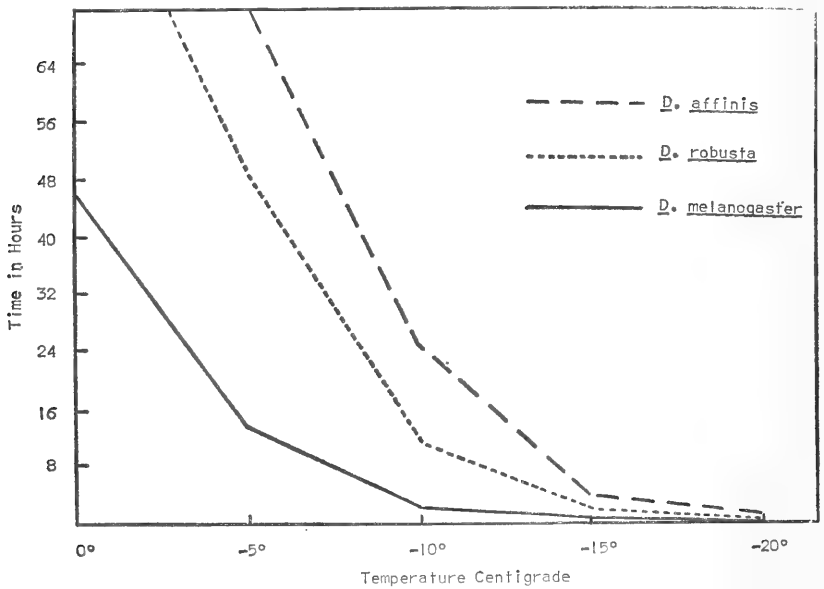

Fig. 1. Lethal dosage fifty percent of *Drosophila* species exposed to low temperatures.

survival at all levels indicated, with *robusta* somewhat intermediate between *affinis* and *melanogaster*. *D. melanogaster* shows only negligible survival below –5° C for periods greater than twenty-four hours.

Another experiment was conducted to determine approximately the nature of the survival response to freezing of several other species. In two separate experiments a total of fifty flies each of the species *D. affinis, robusta, melanogaster, hydei, immigrans* and *cardini* were used. *D. hydei* and *immigrans* are both cosmopolitan domestic species presumably of tropical or sub-tropical origin. *D. cardini* is a wild subtropical species of Florida and the West Indies. Thriving unaged flies were exposed to –5° C. for a period of eighteen hours. The results of this experiment indicate that *hydei, immigrans* and *cardini* are

slightly less cold hardy than *melanogaster* and considerably less than *affinis* or *robusta* (Table III).

Table III

	Degree of Survival				Percentage Actual Survival	
Species	Complete Survival	Crippled	Stunned	Dead	Survived	Perished
D. affinis	28	19	2	1	94	6
D. robusta	23	25		2	96	4
D. melanogaster		16	28	6	32	68
D. hydei			39	11		100
D. immigrans			22	28		100
D. cardini			39	11		100

An experiment using the species *D. tripunctata*, a native species, tested for five days at 1°C in contrast with *affinis, robusta* and *melanogaster* indicated that this species has roughly the same survival potential as *robusta.*

Another test was designed to determine the possible hibernation potential of adult *Drosophila.* One hundred flies each of the species *affinis, robusta* and *melanogaster,* which had been selected so that sex ratios were equal, were aged for two to thirty-six hours past eclosion, permitted to feed on yeast for two additional hours, then were placed in a constant temperature refrigerator at +4° C. for a period of thirty days. At the close of this time the flies were examined. Approximately one-fourth of the *affinis* survived, although only 36 per cent of this number were undamaged, whereas only a single *robusta* and none of the *melanogaster* lived.

Discussion

The perplexing problem of overwintering of *Drosophila* has been the primary theme of this study. In winter collections during both 1957-58 and 1958-59 during the December through March period *D. affinis-algonquin* (sibling species) was the most commonly obtained fly. On some occasions these flies were taken shortly after spells of cold considerably below freezing. These flies almost invariably were shiny colored, showed no broken bristles or appendages and were well

fed. It is conceivable that such flies had recently emerged from the pupae with rising temperatures. On the basis of winter collections it is evident that *affinis-algonquin* is the most cold hardy of the *Drosophila* commonly found in Kentucky. This evidence is confirmed by laboratory cold survival tests with *affinis*.

If *D. affinis* is capable of surviving the winter in greater numbers than other species, this may account for the initial dominance of this species in *Drosophila* collections made early in the spring. The scarcity of the species during mid-summer may be due to competition with better adapted species for food or breeding sites. These summer competitors may not, however, have the benefit of cold resistance, and with early fall frosts *affinis* renews its dominance. The cold hardiness of *affinis* probably also accounts for its prevalence over other native species at higher altitudes as was shown by Carpenter and Giordano (1955).

No attempt was made to distinguish between the sibling species *D. affinis* and *algonquin* until the last eight collections of 1959. On the basis of the evidence available it seems that *algonquin* makes up a greater part of the combined population during the colder months and is more cold hardy than *affinis*. This is in agreement with Miller (1958) who has recognized that *algonquin* is the more northern of the two species, Kentucky being near the southern limits of its range. *D. affinis*, however, disregarding *algonquin*, is still more coldhardy than *D. robusta* with which it shares its range. *D. affinis* is probably also slightly more resistant to cold than *putrida* as is indicated by field data.

Carson (1958) states that *D. robusta* overwinters as an adult, as is evidenced by the dark color of the flies found in collections early in the spring, and that such overwinter flies frequently show broken wings or bristles. The *robusta* obtained at Dry Branch during the months of March and April 1959 were carefully examined. All flies appeared to be undamaged. The flies appeared to be neither exceptionally dark or light in color as compared with flies obtained at other seasons of the year. If *robusta* overwinters as an adult, it must necessarily be well insulated against cold. Thirty days at +4° C. was sufficient to kill all except one of 100 *robusta* in the laboratory. Freezing or sub-freezing temperatures are lethal to these flies in a much shorter time. The presence or nature of hibernacula sufficient to offer protection to adult *robusta* in the Dry Branch area is not known. The presence of overwintering pupae offers itself as perhaps a more plausible possibility, although evidence on this point is not yet available.

D. putrida was the second most abundant fly in winter collections. Unfortunately this species is not readily adapted to laboratory culture and direct cold response was not tested. This species is apparently cold hardy, and by mid-April becomes the dominant fly in *Drosophila* collections.

Laboratory experiments demonstrate that *D. melanogaster* is more sensitive to cold than the native species. The survival of this species shown in this work is in essential agreement with similar studies by Novitski and Rush (1949). It appears doubtful that *melanogaster,* which probably has a tropical origin, is capable of overwintering in the wild in temperate forests of eastern North America. Populations of this fly which become established in forested areas are probably completely eradicated by a winter of any appreciable severity. Populations can then be reestablished only by reintroduction through the agency of man from the domestic situations where it survives.

In studies at Dry Branch and elsewhere large populations of *D. melanogaster* are usually shown to be present by August and September. Studies by Jones (1958) showed that in September 1957 *melanogaster* constituted approximately sixty per cent of the Dry Branch *Drosophila* population. In two years previous to this similar peaks were noted in other unpublished studies. These three years were preceded by moderate winters. We found, however, that in the summer of 1958 *melanogaster* did not establish a population peak and constituted but a small portion of the total population. As has been previously noted the winter of 1957-58 was more severe than average in Kentucky and may account for a reduction in numbers of *melanogaster* to the extent that it was unable to establish a dense population during the year. In addition, during the latter year, collections in areas frequented by humans were avoided. This evidence is further support for the hypothesis that *melanogaster* does not usually survive a severe winter in natural situations.

Two other domestic species, *D. immigrans* and *hydei,* which were treated by exposure to low temperature, were shown to be more sensitive to cold than *melanogaster.* Spencer (1941) has stated that *hydei* overwinters in buildings and other man-made habitats. It is doubtful whether either species can survive rigorous winters in the wild, and, like *melanogaster,* are reintroduced annually by man. In unmolested areas they do not occur. Both species have essentially the same cold resistance as the wild sub-tropical species, *cardini.*

The nature of hibernacula of overwintering *Drosophila* was not determined not withstanding extensive collections for materials which might contain overwintering pupae or eggs. If *Drosophila* overwinter

as adults, the only conceivable locations suitably protected would be hollow trees or stumps, or deep ground litter. Numerous samples of both of these types of materials did not produce any *Drosophila.* Needless to say, but a minute portion of the total hibernacula could be sampled, and the probability of obtaining overwintering flies was slight. Hardy overwinter pupae of *Drosophila,* if such exist, may be attached beneath bark or in crevices in dead wood. More detailed information concerning their summer breeding sites would provide valuable clues for locating possible overwintering eggs or pupae.

Summary

1. Adult *Drosophila* were obtained in winter collections at Dry Branch, Fayette County, Kentucky, in 1957-58 and 1958-58. Live flies feeding in the traps seldom occurred at temperatures below 40° F. *D. affinis-algonquin, D. putrida, D. robusta* and *D. tripunctata,* in this order, were the most common species taken. Of these D. *affinis-algonquin* was the most abundant by a considerable margin.
2. Sample collections of material which might contain overwintering eggs, larvae or pupae did not prove fruitful.
3. A series of direct temperature response experiments was conducted in the laboratory by exposing adult flies to constant temperature ranges for various lengths of time. In these experiments *D. affinis* was the most coldhardy, and *D. melanogaster* was the most sensitive. *D .robusta* was intermediate.
4. Comparative tests of other domestic and native species indicated that *D. hydei* and *D. immigrans* are less cold hardy than native species and are comparable to the sub-tropical species *D. cardini. D. tripunctata* has approximately the same cold resistance as *D. robusta.*
5. *D. affinis* showed better hibernation potential than either *D. robusta* or *D. melanogaster* when held thirty days at +4° C.
6. Experimental and field data demonstrate that *D. affinis* is better adapted to cooler temperatures than other species present in Kentucky. This may explain the high frequency of this species in the spring and late autumn.
7. The manner in which *D. robusta* overwinters was not determined. Evidence from the laboratory tests suggests that exposure of adults to freezing temperatures over prolonged periods of more than two or three days is virtually lethal. Some few adults may survive in extremely protected situations, or overwintering pupae may exist.

8. *D. melanogaster* and other domestic species of tropical or subtropical origin probably do not survive winters of any appreciable severity in the temperate forests of eastern North America. These species are probably reintroduced into natural habitats annually by man, and upon becoming established compete successfully with native species during the warmer months.

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ACADEMY AFFAIRS

1960 Fall Meeting

The forty-sixth annual meeting of the Kentucky Academy of Science opened with a visit to the Potamalogical Institute in Louisville from 4:00 p.m. to 6 p.m. on November 4.

Approximately 85 Academy members and guests attended the dinner that evening and heard Dr. Richard L. Barber speak on the subject, "Modern Science and Modern Philosophy".

The business meeting was opened on Saturday morning by P. Panzera at 8:00 a.m.

The minutes of the 1959 meeting were read and approved.

The treasurer's report prepared by R. A. Chapman, was read by R. Barbour. It was moved that the report, previously audited by P. Sears and W. Wagner, be accepted. The motion carried.

R. Barbour then reported that $1.70 of the membership dues of $2.00 are being spent for publication of the "Transactions" leaving an insufficient amount for other Academy activities. He moved that regular membership dues be increased to $3.50, that domestic subscription rates for the "Transactions" be increased from $2.00 to $3.50 and that the foreign subscription rate be increased from $2.50 to $4.00. The motion was seconded by J. Carpenter. The motion carried unanimously. W. Wagner suggested that some of the income from increased dues should be used to support the Junior Academy.

R. Boyer reported that there are over 38 Junior Academy clubs in Kentucky. He reported that the science fair had been held in the east exhibition wing at the fairgrounds. There were over 300 exhibits in the two divisions, one including Jefferson County and another including the rest of the state. He reported that about $700. was used for prizes and expenses and that this money was raised by donations from the Kentucky Research Foundation (for publishing the bulletin), N.E.A., Jefferson County Medical Society, Brown and Williamson, and several chemical companies. He suggested that a Junior Science Bulletin editor be appointed and that a Junior Academy money raiser be appointed in addition to the advisers to replace him. P. Panzera reported the appointment of M. Christopher as the Junior Academy director and that assistants would be appointed.

M. Wharton reported on the A.A.A.S. meeting held the previous December. She also reported that the treasurer would be happy to receive contributions for furnishing the Thomas Hunt Morgan room.

The resolutions committee (J. Carpenter, D. Lindsay, and A. Whitt) presented three resolutions:

1. Whereas, the Junior Academy of the K.A.S., as an integral part of this Academy, has always performed at a high level and brought credit to the K.A.S. under its counselor, Mr. Robert Boyer, and Whereas Mr. Boyer is retiring from this position after several years of outstanding service, be it therefore resolved that the K.A.S. extend to Mr. Boyer a vote of thanks for his excellent record as a leader of potential scientists.
2. Whereas, the University of Louisville under the guidance of a committee composed of Drs. Clay, Jackson, Vance, and Shoemaker has performed efficiently and effectively in arranging for the annual meeting of the K.A.S. at the University of Louisville, be it therefore resolved that the K.A.S. extend to this committee, and to the host institution, the University of Louisville, its sincerest thanks for a well planned and executed annual meeting.
3. Whereas, the K.A.S. heartily endorses the growing interest in the state and nation toward the encouragement of strong subject matter courses in our

schools and colleges, especially in the training of teachers, be it therefore resolved that the K.A.S. attempt to assist, in every way possible, the improvement of the teaching of science in the schools and colleges of Kentucky.

The resolutions were adopted. J. Black presented an additional resolution, endorsing the proposed constitutional revision, which was also adopted.

The research committee (R. Wiley and H. Hancock) reported consideration of two proposals and recommended that $60. be granted to each. After some discussion it was decided that the committee should confer with H. Hahn and T. Kargl before making a final decision on the sizes of the grants. Following the conferences (after the business meeting) it was announced that each would receive $60. T. Kargl's project is entitled "Carotenoids: Structure Determination by Light and Infrared Absorption Analyses." H. Hahn's project is entitled "Mirror Drawings Techniques in Evaluating Behavior Reactions in Frustrating Situations".

A list of new members was submitted for approval by the Academy. Lucia Arderson, William O. Atlinson, Luther W. Baxter, Thomas R. Beebe, John J. Begin, Fred Boercker, Ellis V. Brown, Lourine Cave, James R. Charles, M. P. Christopher, Alfred E. Coleman, Graham B. Dimmick, William G. Downs, Jr., W. G. Duncan, Hartley Eckstrom, Carl F. Essig, Jr., Harold G. Planary, Ralph Forney, Joseph E. Hanegan, Fannie R. Harmon, Carlton Heckrotte, James P. Henley, Sumner Hayward, Donald G. Hicks, Ronald Higdon, Harris E. Hill, Anna L. Hoffman, Karl F. Hussung, Daniel F. Jackson, Thomas H. Johnson, Ernst Jokl, Frank Kodman, Jr., Robert A. Kuehne, James F. Lafferty, Travis J. Leach, William R. McNeely, William R. Martin, Mrs. E. E. Mayo, Louis B. Miller, Richard Newcomer, William Norris, Thomas G. Nye, William Owens, William H. Pell, Charles Reidlinger, R. B. Renda, Gertrude Ridgel, Dan Schreiber, Riley S. Smith, Jr., Charles Sowards, Kenneth J. Starks, G. W. Stokes, arion F. Tabb, Ralph A. Tesseneer, Jack R. Todd, Allen M. Wallace, John B. Wells, Otis Wolfe were accepted as members of the Academy.

The nominating committee (W. Owsley and W. Sumpter) gave the following nominees:

President Elect: C. Whittle
Vice-President: L. Dawson
Secretary: G. Levey
Treasurer: R. Chapman
A.A.A.S. Representative: M. Wharton
Board of Directors: C. Lange, A. Whitt

R. Weaver moved that the slate be elected unanimously. The motion was seconded and carried.

H. La Fuze suggested that the Academy try to encourage research in member colleges. J. Carpenter suggested that the Academy take steps which might result in reducing teaching loads so that research would be more possible. A. Cole suggested that the Academy do some recruitment in high schools for the sciences so that more students might end up in graduate schools and in medicine.

Dr. Philip G. Davidson, President of the University of Louisville, welcomed the Academy to Louisville.

The business meeting adjourned at 9:20.

Meetings of the sections were then held with contributed papers in Bacteriology and Medical Technology, Botany, Zoology, Chemistry, Psychology, Physics, and Geology.

The officers of the sections who were elected at the sectional meetings are as follows:

Bacteriology and Medical Technology
Genevieve Clark, Chairman
Margaret Hotchkiss, Secretary

Botany
Carl Henrickson, Chairman
Arland Hotchkiss, Secretary

Chemistry
Carl Hussung, Chairman
Arthur W. Fort, Secretary

Physics
Bruce B. Vance, President
Richard Hanau, Secretary, Treasurer

Psychology
Ray H. Bixler, Chairman
Paul McNeely, Secretary

Zoology
Robert Kuehne, Chairman
Dwight Lindsay, Secretary

Report of the Treasurer for the Year 1959-1960

Balance October 1, 1959		$845.14
Income October 1, 1959-October 1, 1960		
Regular membership dues	$ 642.40	
Sustaining membership dues	210.00	
University of Louisville—Transactions	200.00	
AAAS Research Grants	80.00	
B. Preiser Co.—advertising	50.00	
Reprints—Transaction articles	32.44	
Subscriptions—Transactions	12.00	
Morgan Fund—contribution	10.00	
	$1,236.84	$2,081.98
Expenses October 1, 1959-October 1, 1960		
Transactions—Publication of Volumes 20	$1,157.74	
Secretary—printing, postage, etc.	141.82	
Junior Academy—travel, etc.	89.98	
Research grants	80.00	
Treasurer—mimeographing, postage	15.82	
AAAS Academy Conference dues	6.40	
	$1,491	$ 590.22
Balance October 1, 1960		$590.22
Status of savings account in Lexington Federal Savings and Loan Association		
Balance October 1, 1959		$583.24
Interest—1959-1960	22.08	
Balance October 1, 1960		$605.32

Respectfully submitted,
RICHARD A. CHAPMAN, Treasurer

Approved by:
Paul G. Sears 10/28/60
William F. Wagner 10/28/60

Sectional Meetings

BACTERIOLOGY AND MEDICAL TECHNOLOGY SECTION

Natural Science Building Room 300
9:10 A.M.

O. F. Edwards, Chairman
Genevieve Clark, Secretary

Comparison of membrane filter and Most Probable Number methods on Ohio River Water. W. L. Williams, Superintendent of Purification of water, Kentucky Testing Laboratory, Louisville, Kentucky.

A simplified method for counting anaerobic rumen bacteria using sealed glass tubing. D. W. Claypool, D. R. Jacobson, and R. F. Wiseman, Departments of Dairy Science and Microbiology, University of Kentucky.

Studies on the relationships of bacterial cell walls, antigenic structures and bacteriophage absorption sites. Sidney Crouch and James C. Humphries, Department of Microbiology, University of Kentucky.

BIOLOGY SECTION I

Natural Science Building Room 110
9:10 A.M.

Liza Spann, Chairman
Lloyd Alexander, Secretary

Initial Orientation of *Myotis austoriparius.* Ambrose, Harrison W., III, Department of Zoology, University of Kentucky.

Equipment and Techniques in Photographing Amphibians and Reptiles. Barbour, Roger W., Department of Zoology, University of Kentucky.

A Preliminary List of the Mammals of Lewis County, Kentucky. Barkley, William Byrd. Department of Zoology, University of Kentucky.

A Preliminary List of the Mammals of Robinson Forest, Breathitt County, Kentucky. Hardjasasmita, Hidajat Sjarief. Department of Zoology, University of Kentucky.

Fascioliasis in Indonesian Livestock. Edney, James Marion. Department of Zoology, University of Kentucky.

Population size and Growth Rate in the Fairy Shrimp, *Eubranchipus vernalis.* Kuehne, Robert Andrew. Department of Zoology, University of Kentucky.

Cold Tolerance in *Drosophila.* Moore, William Joseph and Carpenter, John Melvin. Department of Zoology, University of Kentucky.

Recent Lethals from Natural Populations of *Drosophila melanogaster.* Frank Seto. Department of Biology, Berea College.

Investigations into the Status of *Gyrinophilus lutescens* (Refinesque). Newcomer, Richard Joseph. Department of Zoology, University of Kentucky.

Electrocardiograms of the Embryonic and Fetal Rat Heart. Hall, E. K. Department of Anatomy, University of Louisville School of Medicine.

Studies in the Biological Control of the House Fly Using Microchelid Mites. Rodriguez, Juan Guadalupe and Wade, Claude F. Department of Entomology, University of Kentucky.

The Role of Oribatid Mites in the Forest Soil Ecosystem. Wallwork, John Anthony. Department of Zoology, University of Kentucky.

BIOLOGY SECTION II

Natural Science Building Room 108
9:10 A.M.

Lizo Spann, Chairman
Lloyd Alexander, Secretary

A proposal for a flora of Kentucky. Browne, Edwards T., Jr. Department of Botany, University of Kentucky.

The Influence of Sucrose on the Root and Shoot growth of Aseptic explants of *Helianthus annuus*. Henrickson, Carl E. Department of Botany, University of Kentucky.

Colonies and Populations of May-apple (*Podophyllum peltatum* L.) Warden, John C. Department of Botany, University of Kentucky.

Chromosomes in Agapanthus. Mukerjee, Debdas. Department of Botany, University of Kentucky.

Chromatographic methods for studying the genus *Haworthia*. Hopkins, Jerome D. Department of Botany, University of Kentucky.

Chromatographic studies in the Coarctatae Section of the genus *Haworthia*. Isbell, Charles J. Department of Botany, University of Kentucky.

Biological Assay of Water. Jackson, Daniel F. The Potamological Institute, University of Louisville.

Preliminary Studies on Primary and Secondary Fluorescence of Phytoplankton. Parr, Wordie. The Potamological Institute, University of Louisville.

A Comparison of the Gorwth of Algae in Chambers exposed and unexposed to sunlight. Seilheimer, Jack. The Potamological Institute, University of Louisville.

A proposed System for Plant Identification. Gunn, Charles R., Ross Seed Company and University of Louisville.

Respiration Rates of Various Aquatic Invertebrates. Smith, Charles Jr., The Potamological Institute, University of Louisville.

A Quantitative Critique of Gomori's Histochemical Method for Phosphamidase. Atkinson, William B. and Herbener, George H., Department of Anatomy, University of Louisville School of Medicine.

A Study of Soil Fertility by Microbial Activity. Gilkerson, Seth W., Hull, H. L. and Gentry, C. E. Kettering Soils Research Project. Berea College.

CHEMISTRY SECTION

Natural Science Building Room 7
9:10 A.M.

Walter T. Smith, Chairman
Karl F. Hussung, Secretary

"Synthesis of Some Substituted Alkoxybenzoic Acids" by *Walter T. Smith* and Myron H. Bengson (University of Kentucky).

"Molecular Weight and Vapor Pressure Studies of the Solvates of Transision Metal Acetylacetonates." By *Donald R. Rogers*, J. F. Steinbach and W. F. Wagner (University of Kentucky).

"Preparation and Carcinogenic Activity of Alkylated Butter Yellows." *Ellis V. Brown* (University of Kentucky).

"The Reactive Intermediate of the Favorskii Rearrangement." By *Arthur W. Fort* (University of Kentucky).

"Copolymerization Characteristics of Some Divinyl Monomers." By *G. L. Mayberry* and Richard H. Wiley (University of Louisville).

"Effect of EDTA on the Solvent Extraction of Erbium and Holmium Acetylacetonates." By *E. Jarvis*, J. F. Steinbach and W. F. Wagner (University of Kentucky).

"Monomer Reactivity Ratios for the Styreneisoprene Copolymerization." By *Burns Davis* and Richard H. Wiley (University of Louisville).

"Tungsten and Iridium in Stone Meteorites by Neutron Activation Analysis". By *A. Amiruddin*, J. R. Rushbrook and W. D. Ehmann (University of Kentucky).

"A New Stereoisomer of 3-Methyl-5-Phenyl-2, 4-Pentadienoic Acid." By *C. S. Staples* and Richard H. Wiley (University of Louisville).

"Halomethane Solvates of Tervalent Metal Acetylacetonates." By *Francis Clarke*, J. F. Steinbach and W. F. Wagner (University of Kentucky).

"Nuclear Magnetic Resonance Characteristics of the 3-Methyl-5-Phenyl2-, 4-Pentadienoic Acids." By *T. H. Crawford* and Richard H. Wiley (University of Louisville).

In each case, the speaker's name is in *italic*.

PSYCHOLOGY SECTION

Natural Science Building Room 107
9:10 A.M.

Clara Chassell Cooper, President
Lourine Cave, Secretary

The Relationship Between Extent of Self-Disclosure Output and Group Cohesiveness. William T. Query, VA Hospital, Lexington. Discussant: Richard M. Griffith.

Reactions of College Students to Their Course in High School Psychology. Paul McNeely, Asbury College. Discussant: James S. Calvin.

Patterns of Religious Ideas and Personality Traits in Berea College Students: Replication of an Earlier Study. Clara Chassell Cooper, Berea College. Discussant: W. Gordon Ross.

Indifference to Prestige and Attitudes Regarding Segregation. Ray H. Bixler, University of Louisville. Discussant: Raymond A. Wilkie.

Analysis and Synthesis of Judgment. Joan Lee, University of Kentucky. Discussant: Lawrence C. Grebstein.

Systematic Application of Tachistoscopic Techniques for an Objective Approach to Personality etermination. Hans Hahn, Transylvania College. Discussant: Clara Chassell Cooper.

PHYSICS SECTION

Natural Science Building Room 109
9:10 A.M.

An Observation on the Non-linear Propagation of Sound in Water.—Carl E. Adams, University of Louisville.

The Influence of Thin Films on Sound Absorption in Flexible Foams.—M. Schwartz and D. Janzen, University of Louisville.

The Activation Energy of Thin Germanium Films.—B. Nichols and N. Mostovych, University of Louisville.

The Effect of an Aluminum Oxide Undercoating on the Electrical Properties of Thin Metallic Films.—C. Naber and N. Mostovych, University of Louisville.

Expansion of the Point Charge Rock Salt Lattice Potential in Kubic Harmonics.—C. S. Riley and E. F. Sieckmann, University of Kentucky.

Preliminary Calculations of Wave Functions and Energy Eigenvalues for He^+ in a Rock Salt Lattice.—E. F. Sieckmann, University of Kentucky.

Discrimination between Neutron and Gramma Ray Pulses in an Anthracene Scintillator.—M. Hadi and M. T. McEllistrem, University of Kentucky.

GEOLOGY SECTION

Menges Hall Room 106

9:30 A.M.

James E. Conkin, Acting Chairman

Fossil Land Snails from the Loess at Vicksburg, Mississippi. By James E. Conkin and Barbara M. Conkin,* University of Louisville.

Interpretation of Self Potential Maps. By Marion Stallard, Independent Geologist, Fern Creek, Ky.

Coral Zones in the Richmond Beds in Kentucky, west of the Cincinnati Arch. By Ruth Browne, Research Associate, University of Louisville.

PreNiagaran Arch in Kentucky. By Harvey C. Young, Geologist, Geological Consultants, Inc.

Mississippian Foraminifera of Michigan. By James E. Conkin and Philip Malone,' University of Louisville.

Arenaceous Foraminifera from the Louisiana Limestone (Mississippian) of Missouri. By James E. Conkin, University of Louisville.

Geology of the Monroe Dam Area, Monroe County, Indiana. By Harry Thomas, Army Corps of Engineers, Louisville.

AFTERNOON SESSION

1:30 - 4:00 P.M.

Organizational meeting of the geology section, Kentucky Academy of Science. Election of officers for 1961.

Chairman
Secretary

Formation of Committee on Geologic Education to study school curricula in Kentucky.

Formation of Committee on Geologic Research in Kentucky.

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* Indicates speaker.

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INSTRUCTIONS FOR CONTRIBUTORS

The TRANSACTIONS OF THE KENTUCKY ACADEMY OF SCIENCE is a medium of publication for original investigations in science. Also as the official organ of the Kentucky Academy of Science, news and announcements of interest to the membership are published therein. These include programs of meetings, titles, abstracts of papers presented at meetings, and condensations of reports by the Academy's officers and committees.

Papers may be submitted at any time to the editor. Each manuscript will be reviewed by one or more editors before it is accepted for publication, and an attempt will be made to publish papers in the order of their acceptance. Papers are accepted for publication with the understanding that they are not to be submitted for original publication elsewhere, and that any additional printing shall be at a later date and shall be designated in an appropriate credit line as a reprint from the TRANSACTIONS OF THE KENTUCKY ACADEMY OF SCIENCE.

Manuscripts should be typed, double-spaced, with wide margins, on paper of good stock. The original and one carbon copy should be submitted, and the author should retain one additional carbon copy. It is desirable that the author have his colleagues read the manuscript for clarity of expression and typographical or other errors.

Titles must be clear and concise, and provide for precise cataloging. Textual material should be in clear, brief, condensed form. Footnotes should be avoided. Tables and illustrations are expensive and should be included only to give effective presentation of the data. Articles with an excessive number of tables or illustrations, or with poorly executed tables or illustrations, may be returned to the author for modification.

Line drawings and half-tones will appear as *text-figures*. Drafting should be carefully done (hand lettering generally is not satisfactory). Photographs should have good contrast and be printed on glossy paper. Text-figures are to be numbered consecutively and independently; on the back of each its number and the author's name should be written lightly in pencil. Each text-fiure must be referred to specifically in the text and must be provided also with a legend, the latter to be supplied as typed copy separate from the figures. Figures should be arranged into groups whenever possible and the legend for each group written as a separate paragraph. The amount of reduction desired should be indicated and should be consistent with the page dimensions of this journal. Indications of magnification should apply to the reduced figure.

The aim of the paper should be made clear in the introductory portion. If the paper is of more than a few pages it should contain a brief "Summary," which should be lucid without recourse to the rest of the article. In the interest of bibliographic uniformity, arrange all references under a "Literature Cited" heading, alphabetically by author and date, unnumbered, with textual citation by parenthetic insertion of author and date, as (Jones, 1940), or Jones (1940). Use initials for given names. Titles must be included. Abbreviate names of journals, using the form employed by Chemical Abstracts or Biological Abstracts. Separate the volume number from page numbers by a colon. References to books should include also the place of publication and the publisher.

The author is responsible for correcting the galley proof. Extensive alterations from the original are expensive and must be avoided or paid for by the author. Galley proofs must be returned promptly. Blanks for reprint orders will be supplied with the galley proof.

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University of Kentucky
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THE RESPONSE OF THE ADRENAL CORTEX TO STRESS IN RATS

GENE C. PALMER and WM. G. DOWNS, JR.
Biology Research Center, Department of Biology, Tennessee Polytechnic Institute

Anatomy of the Adrenal

The adrenal gland is composed of two separate structures, the cortex and the medulla. The medulla is part of the sympathetic nervous system and will be excluded from this paper. The purpose of these experiments, the effects of physiological stress on the three zones of the adrenal cortex, is achieved by histological methods. Background data on some of the functions of the three adreno-cortical zones are presented in part from the literature, and in part from current research in this laboratory, while the response of the adrenal cortex to insulin stress, is from our own studies.

The outer portion of the adrenal is the cortex, which is divided into the zona glomerulosa, consisting of cuboidal clusters of cells. Beneath this is a thick layer, the zona fasciculata in which the cells are arranged in fairly straight cords and run at right angles to the surface. The last is the zona reticularis, which is a thin layer, with the cells varying in appearance and the cords of the cells dispersed in all directions (Ham, 1959).

Functions of the Zones

The zona glomerulosa secretes minerals and corticoids which control the electrolyte balances of NaCl and Potassium. A primary function of these mineral-corticoids is to cause the distal tubules of the kidneys to reabsorb increased quantities of sodium ions. An important hormone in this zone is aldosterone (Fulton, 1955). A deficiency of aldosterone causes Addison's disease in which sodium is lost from the body into the urine and potassium accumulates in the blood. Eisenstein (1957) showed that rats fed a sodium deficient diet gained weight slowly and that a marked adrenal hypertrophy occured in sodium restricted rats, while the potassium level became elevated and the other steroid secretions occurred at a relatively low rate, with an increased amount of aldosteroids being secreted on this sodium deficient diet.

The zona fasciculata secretes the gluco-corticoids, whose function is not entirely understood. However, it is known that they affect protein, fat and glucose metabolism. Metabolic systems become greatly deranged when gluco-corticoids are absent from the body, and one becomes unable to resist almost any traumatic or diseased

condition that tends to destroy tissues. An administration of gluco-corticoids causes an increased amount of amino acids in the extra-cellular fluid and an increased utilization of these acids. These hormones which include hydrocortisone, the principal one, increase the rate of utilization of amino acids to provide energy or to repair damaged tissue. (Gray, 1950) Gluco-corticoids also mobilize fat from fat cells, which along with amino acids in the blood stream, cause the liver to convert this fat into glucose. This function maintains the blood glucose concentration high during starvation and provides adequate nutrition for neuronal cells which can only use glucose for energy. Hydrocortisons also exerts an inhibitory effect on allergic phenonema. Pantothenic acid has been found to be necessary for the function of the adrenal cortex (Fulton, 1955).

The third group of steroid hormones secreted by the zona reticularis are the sex hormones. These cells secrete the hormones necessary for lactation and increased sexual activity. The class of secreted hormones belong to the 17-ketosteroids which include the principal ones estrone and progesterone (Selye, 1951; 1954a).

Since this paper deals with effects of stress on the other two zones, the zona reticularis will be touched on only in passing.

ACTH

According to Chah Hao Li (1951) ACTH is a protein hormone, which has a molecular weight of 20,000, a pH of 4.7, consists of a polypeptide chain with an alanine residue as the end group, is resistant to heat, remains active after pepsin or acid digestion, and is soluble in water. ACTH is secreted by the anterior lobe of the pituitary and causes the adrenal gland to secrete its hormones. It produces glycosuria in normal rats which are fed a high carbohydrate diet, it inhibits the action of insulin, and promotes glycogen storage. As to the manner of the secretion of the adrenal cortex there is no certain knowledge. It is known that an increased rate of secretion of at least the 11-oxy-adrenal cortical steroids is only possible following a release of ACTH. There is evidence that ACTH is highly effective in alleviating a number of clinical disorders, such as rheumatic fever, arthriits, and allergies. Long (1951) states that probably adrenalin stimulates the anterior pituitary to release ACTH. This is generally accepted to be true.

Deane (1951) suggests that the zona glomerulose is not under the influence of the anterior pituitary, but is under humoral control. As his experiments were carried out on rats it is still believed that the zona glomerulosa in the human is stimulated by ACTH. We are inclined to believe that the same mechanism exists in the rat.

Effect of Steroids in Relation to Stress

In a variety of infections a depletion of lipoid or a change in the lipoid pattern of the adrenal cortex is common (Anderson, 1957). The cells of the glomerulosa and the fasciculata multiply and enlarge when stimulated. The fat droplets become small and during moderate stress they increase in number. If the infection is very severe the fat droplets disappear. The secretory reserve may be impaired by a sudden maximal infection (Deane, 1951). There are also histological changes when there is severe shock. These changes are paralleled by a lipoid exhaustion of the gland, which has been stimulated to meet excessive immediate requirements of the body tissue for cortical secretion (Anderson, 1957).

Gray (1950) found that ACTH is always produced by an organism in response to stress or injury and that it plays a master role in the body's defense mechanism. It is also known that mental or emotional upset is just as truly an injury to the body as a fracture or disease. If ACTH is administered to patients without adrenals, it has no effect on stress, it acts only through the adrenal cortex.

Pregnant women who have arthritis will cease to have this ailment until after delivery when it will reappear. The same holds true for jaundice. Knowing that under other conditions of stress, such as those imposed by anesthesia, surgical operations and bacterial invasions, the adrenals would hapidly increase their secretions, the Mayo Clinic tested the effect of ACTH on rheumatic patients and found that it relieved them as long as the injections continued, but the patient returned to his prior state as soon as the injections were stopped. It has also been found to alleviate symptoms of pneumonia, chronic alcoholism, rheumatic fever and tuberculosis.

Selye (1954a, 1954b) found that the body responds in the same general way to a variety of injuries, cold exposure, burns, fractures, infections, poison, terror, and other emotional traumas. The physiological response of a healthy animal is marked by three stages. (Selye's General Adaptation Syndrome). 1. Alarm reaction (changes in blood pressure and leucocyte count). 2. Resistance stage (the symptoms decline but the body is extraordinarily sensitive to other damage). If stage 2 is successful the animal recovers, if not, then stage 3 appears. 3. Exhaustion stage (body loses its capacity for defensive reaction and dies). When the cortex is defective the alarm reaction is feeble, when the adrenals are removed resistence to stress stops and the animal soon dies, thus the adrenal cortex can both cause and cure a disease.

In a new-born infant the adrenals do not mature for five days (or

longer) and thus the newborn child is extremely susceptible to disease.

ACTH will remove the symptoms of tuberculosis and pneumonia, but the microorganisms may still remain in the patient, and some forms of cancer will yield, at least temporarily, to the influence of ACTH.

Duodenal ulcers were thought to be caused by an abnormal hypersecretion of gastric juice of nervous origin, but Dragstedt found that physical and mental stress increased the liberation of ACTH, which effected the liberation of cortisone, stimulating gastric secretion, and this in turn caused duodenal ulcers. This is an example of the harmful effects displayed by mental activity on ACTH.

Some specific stress may influence synthetic mechanisms concerned with the elaboration of the adrenal center in such a way that the gland will secrete increased quantities of an individual hormone (Evans, Simpson, and Evers, 1958).

Selye demonstrated that ACTH or cortisone, and other glucocorticoids when given at highly toxic levels, will usually cause death as a direct result of uncurbed bacterial proliferation. Thus, injections may re-activate dormant pulmonary tuberculosis. We have found that it is difficult to cause shock with even very large doses of ACTH.

ACTH is also effective in conditions such as glaucoma, hepatitis, and liver cirrhosis, but may produce harmful effects in conditions which include acne, diabetes, and heart failure (Selye, 1954b). ACTH can also cause muscle hypertrophy and local damage when administered to combat systemic stress.

Salt loading is also considered a type of stress, and can cause renal and cardiovascular damages. This may be true even when both kidneys are in a healthy state. Adrenal cortical insufficiency will ameliorate this damage even when the intake of salt is constant. Pathology and elevation of blood pressure were found to occur among adrenalectomized, salt-loaded rats. The zona glomerulosa was found to be depleted of its lipoids in response to the heavy NaCl load. The cells of the zona fasciculate were completely filled with lipoid material, while those of the zona reticularis contained rather less lipid material. Adrenal cortical hormones were found by Crane and Ingle (1959) to play a supporting role in the etiology of most experimental and clinical cardiovascular diseases. One principal mechanism whereby adrenal steroids support the toxicity of high salt loads is by Na retaining action and related actions causing electrolyte imbalances.

Share (1958) demonstrated that potassium loss and sodium

retention follow severe injury (in the rat) in the absence of the cortex. Following bone fracture in the rat there is an increased adrenocortical activity. It has been shown that the catabolic effect of ACTH can be inhibited by a diet rich in KCL. Also, the diabetes promoting action of ACTH is similarly suppressed by an excessive potassium intake (Selye, 1954b).

ACTH has a rather clear-cut effect on the leucocytes, during or after stress. Polak (1958) indicated that after administration of ACTH there was an increase in human leukocyte motility. Dougherty (1951) showed that adrenalectomy exposed an unknown stress effect, resulting in an enlargement of the lymphatic organs after administration of histamine, anaphylaxis, and starvation. We, also, have found this to be true. There was an increased number of circulating lymphocytes in the blood 8-12 hours after stress was applied. Lymphocytes, according to Dougherty and White (1944), are under the control of the anterior pituitary, but granulocytes are not. These granulocytes are controlled, or affected, by the adrenal cortex. Experiments by Porter (1953) showed that lymphocyte responses in mice indicated that lesions in the posterior hypothalamus abolish the ACTH response to stress. Lymphopenia was shown to exist as a result of hyperactivity of adrenocortical hormones, exposure to heat and cold extremes, starvation and epinephrine. Ones these effects are reversed there is an increase in lymphocytes. It is believed that cortical hormones cause a lymphocytolysis in tissues and inhibit mitosis. Most of these effects have been verified in this laboratory (Benson and Downs, 1960, Downs and Benson, 1960a, 1960b).

If an overwhelming stress is applied, the lymphopenic response may be abolished. Dougherty and White (1944) believe that lymphopenia is a specific function of the anterior pituitary mediated through the cortex.

ACTH also has a marked effect on eosinophils and other granulocytes (Cowie et al, 1954; Loutch and Emlen, 1951). Injections of ACTH and glyconeogenic cortical extract showed that there was an increase in granulocytes. Jakolison (1954) showed that eosinopenia was present after the injection of 11-Oxycorticosteroids. In adrenalectomized animals only an insignificant rise in eosinophil count was found. Also prolonged cold stress resulted in a significant eosinophilia, but Loutch et. al (1951) showed that prolonged cold stress showed a consistently lower cell count than normal. Experiments by Cowie (1954) with adrenalectomized dogs showed that following administration of ACTH, the eosinophil count was lowered. Henneman (1949), advancing the work of Cowie, showed that the decrease in eosinophil

count occured 3-5 hours after ACTH injections. This was confirmed by Randolph (1944). We have noted the same phenomenon. In hypophysectomized animals, stress and epinephrine produced a decrease of 40-50% in circulating eosinophils (Randolph, op. cit.) An anesthetic dose of sodium pentabarbital significantly decreased the ACTH blood level causing the animals to return to normal more quickly. Van Dyke (1954) from their experiments, believed that bone-marrow activity is under direct control of the anterior pituitary and not mediated through the adrenal cortex. Sawyer and Perkerson (1953) showed that formalin causes eosinopenia in 4 hours.

Smith and Bern (1958) discovered that the zona reticularis of ovariectomized mice will secrete sufficient quantities of estrogen and progesterone to account for noticeable lobuloalveolar development. The reticularis also secretes enough hormone for maintenance of hyperplastic alveolar nodules of the mammary gland.

High blood levels of the adrenal cortical hormones act to inhibit the secretion of ACTH. The hypothalamus, acting on the pituitary, may be the site of steroid inhibition. The steroid feedback mechanism regulating ACTH release is, in part at least, due to blocking the production of a cerebral structure, presumably the hypothalamus of the pituitary stimulating material (Benson and Downs, 1960).

Experimental Methods

Animals used were inbred albino rats of the "Tec 1" strain, originally hybrid between Wistar and Sprague-Dawley strains. All animals were young (12-15 weeks), of both sexes, but largely females. All were fasted a full 24 hours before experimentation but had an adequate supply of water. In similar diurnal periods, initial total and differential leucocyte counts were made, blood being taken from the tail-vein, with the first drop discarded. The method of blood-counting was the same consistently used in the laboratory with excellent results. In it the total and differential count is made on the same specimen, and the propylene-glycol methylene-blue and phloxine method is followed. Immediately after this initial count, the animal is injected with the desired dosage (in this case graded doses of protamine zinc insulin or ACTH). At regular intervals—hourly or two-hour—counts are again made until time of sacrifice. Animals are sacrificed at regular two hour intervals after injection.

At sacrifice, a total and differential leoucocyte count is made on heart-blood, the animals are autopsied, any variations from normal being noted, and pituitary, adrenals, spleen, thymus, and femurs are immediately fixed in formol-Zenkers for 24 hours. Soft tissues are

then carried through the usual embedding techniques and stained by a variety of cytological methods for study. Femurs are decalcified before embedding and staining. For details of these techniques the reader is referred to the work of Ashburn and Downs (1961) on the pituitary and to Downs and Benson (1960a) on the leucocytogenic organs. The adrenals, the basis of the present report, were stained with hematoxylin and eosin and with Harris' hematoxylin and Gomori's trichrome stain.

Adrenals from 14 female and nine male rats were included in the present study, although more than a hundred are included in the overall study. Data on the effects of age, sex, weight, dosage, etc. are on file, and have been reported elsewhere (Downs and Benson, 1960a and 1960b) as have the studies of the effects of insulin-stress on the pituitary (Ashburn and Downs 1961).

Results

Consistently, with even quite small doses of insulin, there are characteristic changes in the cells of the adrenal cortex. These are progressively more clear-cut with increasing dosage. With even quite small doses, i.e. 0.2 to 0.4 units/100 gms. body weight, interstitial spaces may be seen between columns of cells, and even adjoining cells. This condition is more positive as dosage is increased, and is most apparent in the zona reticularis, zona fasiculata less so, and glomerulosa rarely so, and then slightly, even with large doses (1 unit to 1.4 units/100 gms). It is also more apparent as the time-interval after injection increases. In approximately the same degrees, the individual cells of the zona reticularis appear larger and "swollen" looking and nearly or completely devoid of cytoplasm, except for a spidery reticular structure. This appearance is interpreted as being due to a comparative or complete loss of lipids (in proportion to dosage).

The response of the cortical cells to ACTH was somewhat similar to, but not identical with that of insulin. One notable difference lies in the lessened response to increased dosage. It was very nearly impossible to throw our animals into shock with even very large doses of ACTH, while many animals will go into shock with as little as 0.6 units of insulin/100gms. The same changes occurred in the reticularis as with insulin, though in lesser degree, while cells of the zona glomerulosa did not seem to respond at all to even quite large doses of ACTH. This would seem to confirm the findings of Chah Hao Li that this zone is not affected by ACTH in rats. The zona fasciculata still did not respond to as great a degree as the reticularis, but did

show proportionately more change than was true in the insulin injected rats.

In both types of treatment the leucocytes showed a fairly characteristic response, more marked with insulin than with ACTH, as the stress agent. There is usually an initial sharp fall in the total count, followed at varying periods by a slow or rapid increase, frequently well above normal levels, with a gradual return to normal, requiring perhaps 24 hours or more. Immediately the lymphocyte count falls, in larger dosages to a very low level, while there is a coincident rise in the heterophil (neutorphil) count. This is usually an absolute as well as a relative change (Ashburn and Downs, 1961; Downs and Benson, 1960a, 1960b).

Additional work on the effects of hypothalamic lesions and stimulation by one of our group (Benson and Downs, 1960) indicates that the entire series of changes is mediated through the hypothalamic-hypophyseal-adrenocortical axis. Consistently, there is a close correlation between reactions in the leucocyte count, and observable histological changes in the adrenal cortex. In this same series of animals, we have found parallel changes in, at least the three types of basophils in the anterior pituitary.

Conclusions

When the normal albino rat is injected with insulin or ACTH, there are characteristic changes in the adrenal cortex, primarily being depletion of the lipid (and hormone) content of the cells of the zona fasciculata and reticularis, frequently in larger doses, to the point of complete exhaustion. Coincident with these changes are consistent and characteristic changes, in the differential leucocyte count, in which lymphopenia and heterophilia are most marked. Parallel changes in the anterior pituitary accompany these phenomena (Ashburn and Downs, 1961). This series of effects is interpreted as a part of the General Adaptation Syndrome (GAS) of Selye, and are believed to be mediated by the hypothalamic-hypophyseal-adrenocortical axis.

These studies are still in progress, and similar methods are being utilized for a study of the effects of radiation stress on rats.

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FOSSIL LAND SNAILS FROM THE LOESS AT VICKSBURG, MISSISSIPPI

JAMES E. CONKIN and BARBARA M. CONKIN
University of Louisville

Abstract

Two species of land snails, *Gastrocopta corticaria* and *Hawaiia minuscula*, along with a fragmentary specimen of a third species, *?Praticolella berlandieriana*, are reported for the first time from the loess at Vicksburg. The snail fauna of the upper 30 feet of the loess permits an age assignment within the post-Bradyan portion of the Wisconsinan Stage of the Pleistocene.

Introduction

The upper part of the loess at Vicksburg, Mississippi was masured at the southeast side of the road cut at the intersection of U.S. Highways 80 and Bypass 80, two miles east of Confederate Avenue (Fig. 1).

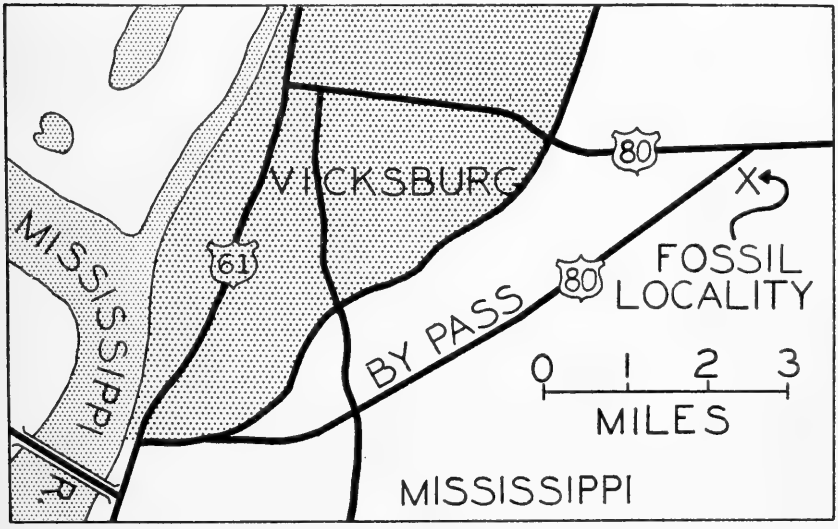

Fig. 1.— Map of the Vicksburg region.

New information obtained from a study of this section of the Vicksburg loess and its associated snail fauna is herein presented.

Measured Section

Sample	Thickness Feet	Inches
1. Soil, dark orange, formed from loess; leached; siltstone casts of rootlets; no fossil snails	1	0
2. Loess, gray-buff, some darker; leached; siltstone casts of rootlets; no fossil snails	4	0
3. Loess, gray-buff; leached; siltstone casts of rootlets; no fossil snails	5	0
4. Loess, gray-buff; leached; rare quartz sand; siltstone casts of rootlets; no fossil snails	2	0
5. Loess, gray-buff; calcium carbonate present; rare quartz sand; siltstone casts of rootlets; fossil land snails	1	0
6. Loess as in Sample 5, but snail fauna not identical	3	0
7. Loess as above, but snail fauna not identical	5	0
8. Loess as above, but snail fauna not identical	5	0
9. Loess as above, but snail fauna not identical	4	5
10. Float derived from overlying loess; calcium carbonate present; siltstone casts of rootlets; fossil land snails.		
Base of section in loess at road level.		
Total thickness of measured section	30	5

Snail Fauna

Table 1 shows the occurrence of the snails in samples 5 through 10. Samples 1 through 4 contained no fossil land snails inasmuch as all carbonates are leached out of the loess to a depth of 12 feet. This great depth of leaching of the carbonates is characteristic of the southern loess sections.

Two species of fossil land snails, *Gastrocopta corticaria* and *Hawaiia minuscula*, and a fragmentary specimen of a third species, *?Praticolella berlandieriana*, are recorded for the first time from the loess at Vicksburg; however, Shimek (1902) listed *G. corticaria* and

Table 1.— Fossil land snails found in samples 5 through 10.

	5	6	7	8	9	10
Allogona profunda			X			X
Anguispira alternata	X	X	X		X	
Discus patulus	X	X	X		X	
Gastrocopta corticaria			X			
Haplotrema concavum				X		X
Hawaiia minuscula		X	X	X		
Helicina orbiculata						X
?Praticolella berlandieriana						X
Retinella indentata			X	X	X	
Retinella sp.	X					
Stenotrema stenotrema		X				X
Stenotrema sp.			X			
Triodopsis (Neohelix) albolabris						X
Triodopsis fradulenta						X
Triodopsis sp.						X
Zonitoides aboreus					X	

H. minuscula from the loess at Natchez (a correlative of the Vicksburg loess).

Species of Land Snails Significant in Age Determination

Table 2 shows the occurrence of several species of fossil land snails in four southern loess sections (Vicksburg and Natchez, Mississippi; Helena, Arkansas; and Tunica, Louisiana). The similarity between the faunas at these localities indicates that they may be of the same, or nearly the same, age.

Of the species herein listed from the loess at Vicksburg (Table 1), a few are of importance in ascertaining the age of the deposit. These species are known from the Recent, but only their Pleistocene ranges are considered here.

Allogona profunda is widespread in the Wisconsinan deposits of the Mississippi, Missouri, and Ohio Valleys, and has been reported from the loess in the Florida Parishes of Louisiana at Tunica (Richards, 1938).

Anguispira alternata is reported from the Aftonian to the Recent (Pilsbry, 1940); however, this species is known in the classic Pleistocene sections of Kansas from only the Wisconsinan Bignell loess (Frye and Leonard, 1952); in Kentucky, the species is known from only the Wisconsinan Tazewell deposits (Browne and McDonald, 1960).

Table 2.— Occurence of 13 species of fossil land snails in four of the most extensively studied southern loess sections.

	Helena, Arkansas (Shimek, 1917)	Natchez, Miss. (Shimek, 1902)	Vicksburg, Miss. (Shimek, 1902, and Richards, 1938)	Tunica, La. (Richards, 1938)
Allogona profunda	X	X	X	X
Anguispira alternata	X	X	X	X
Discus patulus		X	X	X
Gastrocopta corticaria	X	X		
Haplotrema concavum	X	X	X	X
Hawaiia minuscula	X	X		
Helicina orbiculata		X	X	X
H. orbiculata tropica	X			
Retinella indentata paucilirata	X	X	X	X
Stenotrema stenotrema	X	X	X	
Triodopsis (Neohelix) albolabris	X	X	X	X
T. fradulenta	X	X	X	
Zonitoides arboreus	X	X	X	X

Triodopsis (Neohelix) albolabris is reported in Kansas from only the Wisconsinan Bignell loess (Frye and Leonard, 1952).

Helicina orbiculata has been reported from the loess at Natchez, Mississippi by Richards (1938), Vicksburg (Shimek, 1902), and Tuni-

ca, Louisiana (Richards, 1938); this southern loess snail is apparently restricted to the Wisconsinan. A variety, *H. orbiculata tropica,* has been reported from Helena, Arkansas (Shimek, 1917).

Retinella indentata paucilirata has been listed from all four of the southern loess sections on Table 2; this species is also of late Pleistocene age.

Helicina orbiculata tropica and *Retinella indentata,* as well as *Praticolella berlandieriana,* are known from only Wisconsinan deposits. The senior author has collected these species from the Wisconsinan terrace along the Medio Creek in Bee County, Texas. The terrace of the Medio Creek probably correlates with the late Wisconsinan Ingleside Terrace of San Patricio County, Texas (Sellards, 1940). *H. orbiculata tropica* and *P. berlandieriana* were also found by the senior author in the late Wisconsinan deposits overlying the "Uvalde gravels" at the old Fordyce gravel quarry at Old San Patricio, San Patricio County, Texas.

Age of the Vicksburg Loess

PREVIOUS OPINION

Leighton and Willman (1950) correlated the loess at Vicksburg with the Peorian loess in this manner:

> "It [the loess at Vicksburg and Natchez] is essentially the same as the Peorian loess in the upper Mississippi Valley in composition, topographic position, stratigraphic relations, and general appearance."

The age and stratigraphic relationship of the Peorian loess was discussed by Leighton and Willman (1950) as follows:

> "The Peorian loess is definitely of Wisconsinan age. It is a multiple loess in western and southern Illinois and undoubtedly elsewhere, being composed primarily of Iowan and Tazewell loesses, with probably some Cary and possibly some Mankato loess."

In discussing the age of the Pleistocene deposits in the lower Mississippi Valley region, Richards (1938) noted in regard to the Tunica fauna of the Florida Parishes of Louisiana:

> "It is very probable that the loess of the lower Mississippi Valley is of more than one age, possibly having been deposited at various times from the early Pleistocene to the present; some of the loess deposits, then, may be quite recent. . . . It does not appear advisable to attempt to definitely date the loess deposits of Louisiana at this time without further study of the fossils from the loess in Mississippi, Arkansas, and adjacent regions. However, because of

the similarity of its fauna to that of the region today and because of its position overlying the freshwater fossiliferous silts (Port Hudson?), it is probable that the loess in the vicinity of Tunica is of late Pleistocene age."

PRESENT OPINION

Allogona profunda and *Triodopsis (Neohelix) albolabris* are known to occurr only in post-Bradyan deposits (Caryan-Mankatoan) in the northern loess sections. The senior author knows of no Pleistocene deposits older than Wisconsinan in which *Helicina orbiculata tropica, Practicolella berlandieriana,* and *Retinella indentata* occur. *H. orbiculata tropica* and *P. berlandieriana* are of course restricted to the southern loess. Although *Anguispira alternata* has been assigned a long Pleistocene range by Pilsbry (1940), this species is characteristically a rather late Wisconsinan snail.

Certainly the snail fauna of the upper 30 feet of the Vicksburg loess as reported here must be late Wisconsinan in age, and most likely post-Bradyan (Caryan-Mankatoan).

Conclusions

Two species of land snails, *Gastrocopta corticaria* and *Hawaiia minuscula,* along with a possible third species, *Practicolella berlandieriana,* are recorded for the first time from the loess at Vicksburg.

A section of the upper part of the loess shows that the zone of carbonate leaching extends downward at least 12 feet.

The snail fauna of the upper 30 feet of the loess at Vicksburg has closest affinities to the late Wisconsinan (post-Bradyan, Caryan-Mankatoan) faunas in the classic Pleistocene sections to the north.

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SEXUAL CYCLES AND BREEDING SEASONS OF THE GRAY SQUIRREL, *SCIURUS CAROLINENSIS* GMELIN

ALFRED BRAUER
University of Kentucky, Lexington, Ky.
and
ALBERT DUSING
Park College, Parksville, Mo.

The gray squirrel, *Sciurus carolinensis* Gmelin, the predominant squirrel of the southeastern states, presents several problems which bear investigation. First, there occur biannual breeding cycles which if observed as to behavior alone appear to be only roughly delineated, and, which if correlated with anatomical evidence may be more sharply bounded than they appear. Second, observations that the adult male, like the female, runs cycles, have been made principally on the fox squirrel of the North Central States, and should be verified. Third, the anatomical changes in the male reproductive tract may reveal events not yet reported, and fourth, the male and female cycles require correlation as to stages, and these in turn with pregnancy and lactation periods.

A limited number of papers bearing on some of the points enumerated are at hand. Dealing with population behavior are the following: Chapman, 1929; Brown and Yeager, 1945; Bertram and Gault, 1952. Of these that of Bertram and Gault was made in South Central Kentucky and deals with the gray squirrel. By trapping and retrapping wild squirrels, questioning hunters and sometimes examining their takes, a good sample of the population and its behavior was established. They examined females by vaginal smear and males for scrotal indication of cyclical periodicity. The studies of Mossman et al, 1933; Deanesly and Parks, 1933; Allanson, 1933; Mossman, Hoffman and Kirkpatrick, 1955, and those of Kirkpatrick, 1955, deal with histology of reproductive, and accessory reproductive organs throughout the entire year and therefore through two complete breeding seasons.

The problem had its inception here on the university campus in 1951 when Gault live-trapped an examined squirrels throughout the year for information concerning breeding behavior. It was continued in 1954-1955 when others became interested and remained in progress till 1958.

Live trapping was practiced in several sites of the campus and then became centered in a woodlot of the Experiment Station farm, oper-

ated and set aside by the Dept. of Horticulture and Forestry. Trapped animals were examined at the site of trapping, toe indexed, and assigned serial numbers. Notations were made of any marks that might prove useful for establishing identity of the animal when observed with glasses in the wild, or for individuals when retrapped. Systematic observation of squirrels in the wild was regular procedure.

Materials for histological study were obtained by sacrificing animals from time to time as judiciously as possible. A considerable number of squirrels obtained in the earlier part of the study were used and a number were shot for the purpose in wooded areas other than the trapping sites. A final portion was autopsy material from caged animals which were sometimes found in trap or cage in a state of shock.

While the trapping technique was considered most feasible originally, it was also expected that caged animals could be utilized for limited experimentation. This proved futuile. Squirrels caged in small animal cages lived only from 24 to 48 hours. In large cages, 6′ x 6′ x 4′, built for the purpose and set up in the woods, equipped with facilities for play and exercise, they lived for a week to 12 days. Such animals at first seemed to accept confinement, ate and played, then passed into a state of shock and died.

Handling of animals after capture for making vaginal smears or other examination was accomplished by frightening the animal from the rectangular trap into a chicken wire cone placed over its entrance. At the small end of the cone a sizable wad of cotton was placed. As the animal scurried from the trap into the cone and buried its head in the cotton the cone was constricted behind it to give but little room for the animal to squirm. After examination it was released near the site of capture.

The experience of entering a trap and subsequent treatment did not seem to deter squirrels from entering a trap again and again. While a considerable number were caught but once, others became regular visitors. Two were taken seven times each.

Many animals captured were juvenile. These were distinguished by criteria given in Table 1. All male juveniles had abdominal testes and females gave anoestrus smears.

Adult male squirrels were examined with attention given to scrotum and testicular position. A darkly pigmented scrotum relatively free from hair and containing testes is indicative of sexual maturity and breeding condition. One covered by abdominal hair and shrunken, indicates sexual quiescence. Testes are described as being abdominal, inguinal, or scrotal in position.

In the female, a red, turgid vulva is indicative of oestrus. Mam-

Table 1.— Criteria for distinguishing between adult and juvenile gray squirrels by external examination (adapted from Brown and Yeager, 1945).

ADULTS	JUVENILES
Males	
Ventral surface and posterior end of scrotum blackened and generally free fro hair	Posterior end of scrotum with smooth skin, brown to black, free from hair
Females	
Mammary glands enlarged and prominent; not hidden by hair	Teats inconspicuous, more or less hidden by hair
Males and Females	
Tail nearly rectangular, block shaped; sides parallel or nearly so	Tail pointed, triangular; sides not parallel

In addition to the criteria given above the juveniles of both sexes were smaller in size and the tails appeared less bushy.

mary glands with well developed nipples and sometimes covered by surrounding hair indicate late pregnancy or lactation. Milk can be squeezed from the teats of a lactating female by gently kneading them. In late term pregnant females the foetuses may be palpated. Vaginal smears were made from each female by introducing, and then withdrawing, approximately 1 ml. of normal saline from the vagina with a pipette. This was spread on slides and dried at the trapping site. The slides were taken to the laboratory for staining and examination.

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We gratefully acknowledge the cooperation of former students, William L. Gault, Edwin Dale, and William Valleau; to Dr. O. F. Edwards, Dept. of Bacteriology for photomicrographs, and recognize our indebtedness to the late Professor A. J. Olney and Dr. C. M. Davenport of the Department of Horticulture and Forestry for making the Experiment Station woods available to us.

Examination of Males

During the course of study 42 adult males were trapped and examined a total of 144 times. Table 2 shows the percent of examinations made per month for each of three testicular positions, abdominal, inguinal, and scrotal. It may be noted that some of the examinations made during September, October, or November, showed testes in scrotal position. There was a decline in the ratio of scrotal testes during March, and August, and an increase in the months of May and December. Curve peaks for scrotal testes were reached in January

Table 2.— Number and percentage of examinations per month showing various testicular positions.

Month	Position of Testes						
	Abdominal	%	Inguinal	%	Scrotal	%	Total
Jan.			2	18	9	82	11
Feb.			3	23	10	77	13
Mar.	7	44	6	37.5	3	19	16
Apr.	8	73	2	18	1	9	11
May	8	50	6	37.5	2	12.5	16
June	4	12.5	15	47	13	42	32
July	3	27	3	27	5	55	11
Aug.	2	40	2	40	1	20	5
Sept.	7	100					7
Oct.	7	87.5	1	12.5			8
Nov.	5	83	1	17			6
Dec.			3	42	4	57	7
Total	51		47		45		143

and July. A further demonstration of this is exhibited in Fig. 2, where the percentages of examinations per month are charted.

Additional evidence of this cyclic change of the male was demonstrated by the trapping history of two individuals recaptured three times during February and in all three examinations testicular position was scrotal. On March 25, the testes of this squirrel were inguinal, and by April 14, had ascended into the abdominal cavity, and were also abdominal on April 28. On June 22 the testes were again scrotal.

Male No. 36 had scrotal testes, on June 5, and 15, inguinal, on July 10, abdominal, on August 13, and Sept. 16, scrotal, Dec. 26, 1956, and abdominal again on March 15, 1957.

From the protocol records squirrels taken and sacrificed for histological study the following data were obtained: Testes in scrotal position came from squirrels sacrificed Jan. 16, March 21, June 25, Nov. 19 and 28, Dec. 10 and 31. The seminiferous tubules were well developed and large; germ cells of all categories including spermatozoa in abundance were present; maturation was in progress; interstitial cells were large, closely packed and in all respects the glands were those of rodents in breeding condition Fig. 1-1).

A scrotal testis showing different histologic form was one taken March 21, or near the close of the breeding season. Subsequently another in the same condition was obtained from an animal sacrificed July 28. The testis was less turgid than one in breeding condition and the scrotum not as heavily pigmented. The tubules contained the debris of degenerating germinal epithelium, namely speratids and secondary spermatocytes. Spermatozoa were no longer identifiable. Primary spermatocytes were still present in the attached epithelium but obviously in degeneration (Fig. 3).

Squirrels with abdominal testes were sacrificed Oct. 16 (2 specimens), Sept. 1, Nov. 19, and Dec. 10.

The seminiferous tubules of these ranged from large, containing proliferating spermatogonia (1 specimen), to small, shrunken, cord-like structures with almost no lumina. Within the interstitial cell ag-

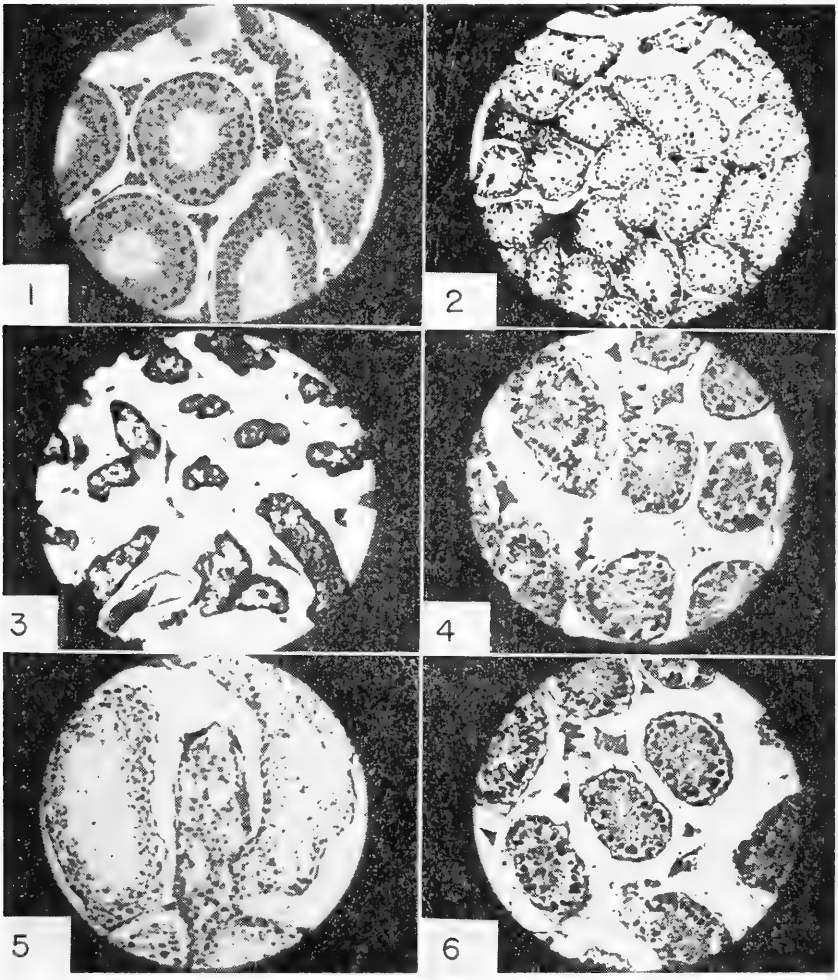

Figure 1.

1. Section of scrotal, breeding, testis.
2. Section of scrotal testis post-breeding condition.
3. Abdominal, cryptorchid testis.
4. Section of abdominal testis in recovery.
5. Inguinal testis, ascending, following section 2.
6. Inguinal testis, descending, following section 4, showing recovery of germinal epithelium.

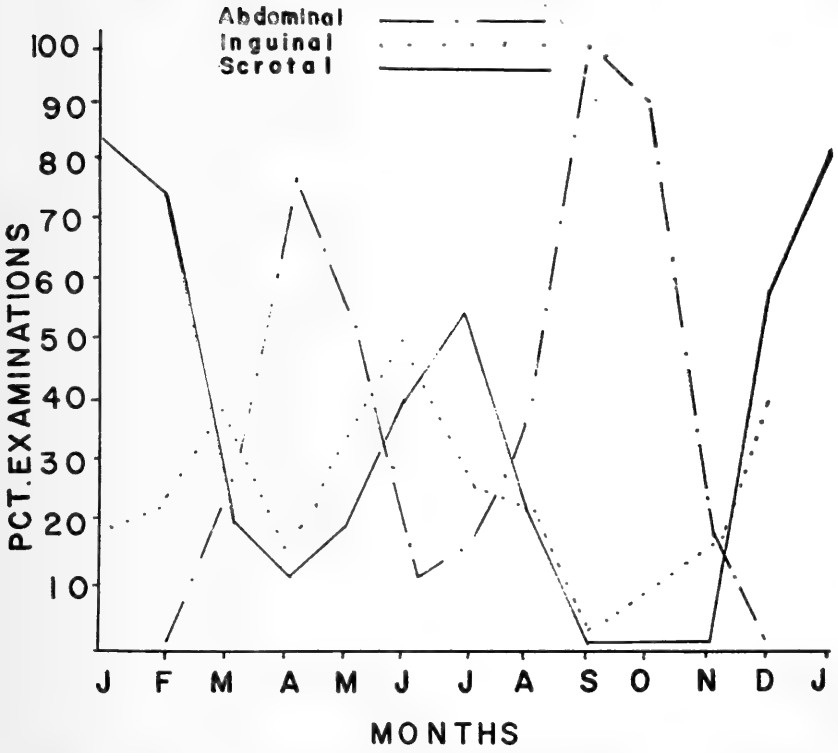

Figure 2.— Seasonal trends of testicular positions from numbers given in Table 2.

gregations individual cells were smaller than those of scrotal testes. The cords stained predominantly with eosin due to much connective tissue present and lack of DNA in the nuclei (Fig. 1-3).

One specimen brought to the laboratory Nov. 22, appeared typical for a squirrel of October or early November in sexual quiescence. The scrotum was shrunken, wrinkled, and covered by abdominal hair. The animal, sacrificed while in a virtual state of coma from nothing more than 14 hours confinement apparently, had abdominal testes in which abundant repair was in progress. The tubules were about two thirds enlarged, spermatogonial division was taking place and Sertoli cells were plentiful and enlarged. Interstitial cells were practically normal and staining was sharply differential. All of this repair was in progress before the testes had begun their descent (Fig. 1-4).

Inguinal Testes:—Obviously two opposing pictures were presented by these, namely, those with descending testes developing progressively, and those with receding testicles undergoing regressive change toward cryptorchism. With descent of the glands to the scrotum the

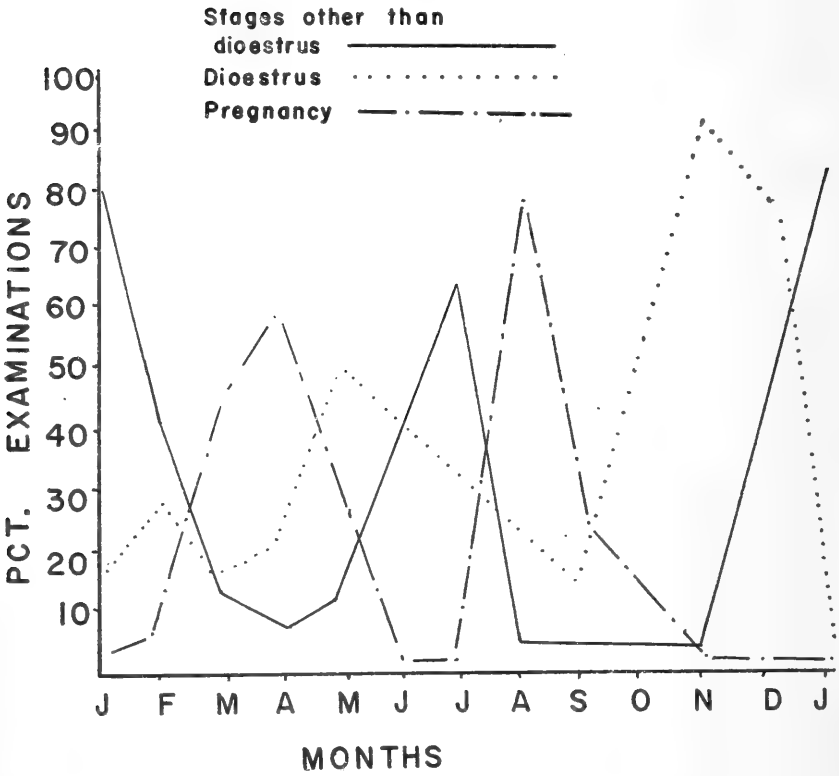

Figure 3.— Seasonal trends of females from analyses of vaginal smears, solid black line showing female breeding potential.

latter showed simultaneous changes in that it became rounded out from its former wrinkled state, showed progressive pigmentation and was shiny. Surrounding abdominal hair no longer covered it completely; its caudal end became somewhat pendent. The testes while still in the inguina became enlarged almost to the size of scrotal, breeding testes; seminiferous tubules contained germ cells of all categories including a few spermatozoa and maturation of spermatocytes was in progress (Fig. 1-5).

Inguinal testes in early recession were enlarged over scrotal testes of mid breeding season but were flaccid. The tubular lumina were large and contained mucous-like substance and debris of spermatozoa, spermatids, secondary and primary spermatocytes. The tubular walls were thin containing only spermatogonia, some pyknotic primary spermatocytes and Sertoli cells. Advancing nuclear breakdown was reflected in the lack of staining capacity and differential contrast in photomicrographs. Regressive testes sectioned were made from squirrels

taken March 24 and 28, April 4, Aug. 1 and 16. Progressive testes sectioned were taken from animals taken May 3, and 28, Oct. 21, Nov. 29 (Fig. 1-6).

Examination of Females

Forty-one females were examined 142 times. Vaginal smears made in these examinations showed two activity periods in the female cycle. Table 3 lists the results of the examinations. The first column of Table 3 gives the number of smears showing stages other than dioestrus. A

Table 3.— Number and percentage of examinations per month showing females in various stages of the breeding cycle.

Month	Diostrus	%	Others	%	Pregnant	%	Lactating	%	Total
Jan.	3	18	9	82					12
Feb.	5	36	8	57	1	7			14
Mar.	2	15	2	15	6	46	3	23	13
Apr.	3	23	1	8	7	54	2	15	13
May	12	57	3	14	3	14	3	14	21
June	11	52	9	42.5			1	5	21
July	3	37.5	5	62.5					8
Aug.	1	25			3	75			4
Sept.	1	17			1	17	4	67	6
Oct.	10	71			2	14	2	14	14
Nov.	5	100							5
Dec.	9	82	2	18					11
Total	65		39		23		15		142

female in proestrus was regarded as approaching breeding stage, and one in metoestrus as just having passed it.

It may be noted that peaks of the female breading season were attained in January, and July (Fig. 3, and Table 3). Pregnancy peaks were attained in April and August, and lactation peaks in March and September. Females listed as pregnant were in mid, or late stages of gestation in which foetuses could be palpated. Fig. 3, shows the percentages per month for breeding, non-breeding, pregnancy, and lactation.

Data concerning the duration of stages of the oestrus cycle are available from only one animal (Fig. 1-8). She was captured June 19 in oestrus, June 21 in metoestrus, and June 23 in dioestrus.

Information regarding the length of gestation comes from one female also. On June 17 the animal was in oestrus. She was released and presumably was the pursued squirrel of a chase in that area which lasted through the following day. Taken again August 4, she was in lactation while the nipples and hair around the mammae indicated recent parturition. The elapsed time was 45 days.

One female is known to have given birth to two litters within a year. She was taken on March 1, in oestrus, was recaptured April 22 and was lactating. The same animal was taken Sept. 20, and was again lactating.

Histological examinations were made of the ovaries of 13 adult females. Many "egg-nests" and primary follicles appeared in all. Oddly, mature or maturing follicles were found in ovaries of all examined except one each for January and December. The larger numbers of mature follicles were found in individuals taken during March and November. Corpora lutea of recent formation were found in all mature ovaries examined except those of March, November, and late December. Corpora lutea of advanced development, some showing early stages of atresia were likewise found in a large number of ovaries examined but data showed no definite pattern of frequency. Specimens showing advanced follicles in considerable numbers were those of February and September.

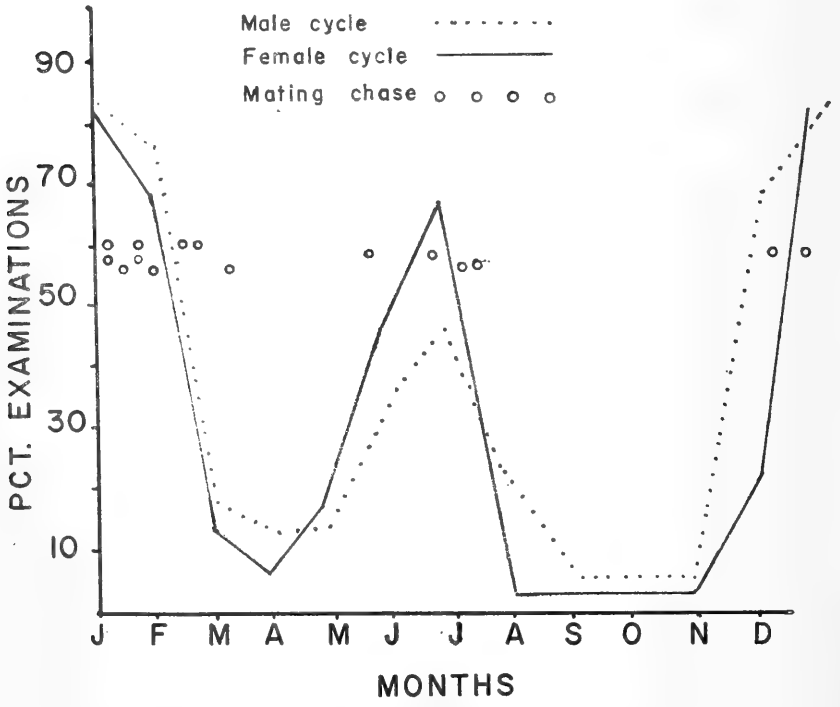

Figure 4.— Seasonal cycles of males and females superinmposed on chart of breeding performance as indicated by mating chases observed by the month.

Breeding Seasons

The most practicable method of determining actual breeding seasons is by observation of mating chases and noting their frequency and occurence. This prenuptial exhibit precedes copulation by 1½ to three days and occurs when a particular female is approaching oestrus and males are in breeding condition. Care must be exercised in distinguishing true chases from simulated ones of short duration practiced by maturing animals.

Chases recorded here were separate ones and each was undoubtedly genuine. They occurred as follows: Dec. 15, 26; Jan. 1, 8, 12, 14, 26 (two chases); Feb. 14, 26; Mar. 28; June 16, 26; July 4, 10, 16, 26 (Fig. 4).

Development of Young

A pregnant female frequenting her presumed den in a walnut tree was kept under observation and was known to have undergone parturition between March 17 and 19. She and den were kept under surveillance. On May 1, two young were seen in the den entrance and on May 5 the two young were observed on a limb near the den entrance. Each of their movements seemed carefully measured and their grasps on the limb very secure. The following week, May 14, the young were accompanied by a third, which apparently had remained in the nest longer than the two, and which undoubtedly was a third litter mate. On that occasion they had developed considerable alacrity in running out on the limb and back to the nest. They were first seen on the ground May 29, or 45 days after birth. They continued to remain near the tree until late in July, after which they remained together but no longer returned to the den. Their identiy was lost after the following February.

Another litter of four was kept under observation from the time they were first seen on the ground, May 25, till December of that year. They were observed on numerous occasions in sexual play throughout November and early December. They were not identified after December 16.

Discussion

Factors taken into account in the determination of sexual cycles are: a) In the male, testicular positions with reference to abdomen and scrotum between which the testes descend and ascend seasonally; b) condition or appearance of scrotum; and c) histological pictures of testes during progression and regression. In the female the factors are: a) Vaginal smears; b) histological sections of the ovary; c) pregnancy and lactation periods.

The correlation of these factors determine the breeding seasons as two, annually. The first of these is the winter season, December and January, the second, from mid June through July. They are about eqaul in length and percentage of population involved.

Other workers, Allen, Brown & Yeager, and Bertram & Gault (op. cit.) have also observed two such annual seasons corresponding closely to those established here. Possibly the cycles of squirrels in Michigan, Ohio, and Illinois, made predominantly from records of fox squirrels, attained their seasonal peaks slightly later. The determinations by Bertram and Gault, for gray squirrels, are almost identical with those established here excepting that their higher peak was that of the summer while here the winter peak is insignificantly higher.

Seasonal overlap is especially marked from February through April. Some workers, Deanesly and Parks (1933), and Allanson (1933), recognized only one annual season for gray squirrels of England, namely spring-summer. Their works were almost entirely histological in which captured animals were brought to the laboratory were sacrificed forthwith and the material prepared. Thus the material from an individual gave but one view of an isolated case. In observations on females they failed to see the sharply delineated stages of the oestrus cycle shown by vaginal smears and which are but feebly indicated by the ovary alone. Vaginal smears and ovarian sections taken together however interpret each other. The coincidence of the seasonal dioestrum of the female and the long period of cryptorchism of the male make the very nature of sexual activity biannually periodic.

For the male the seasonal cycle is dramatic in that it is manifested by testicular descent from abdomen to scrotum and thence back to the abdomen within a period of six to eight weeks with all of the histo-anatomical changes of experimental or spontaneous cryptorchism and recovery. Mossman and Kirkpatrick (op. cit.) expressed amazement at the capacity for recovery shown by the organs of the male tract after so complete degeneration. It must be iterated here that degeneration of testis begins while the latter is still scrotal, is well under way in the inguinum, and almost complete in the abdomen. Recovery takes place while the testis is abdominal and considerably prior to recovery of the scrotum itself. Recovery of strotum begins while the testes are inguinal. Kirkpatrick (op. cit.) noted this and emphasized the point that the changes of regression and recovery are physiologic, and specifically endocrinal rather than the result of mechanical, or climatic change.

As herein determined the gestation period of one female was 44-45

days which is within 1 day of the 43-day period usually given for the gray squirrel. Von Eibel-Eibesfeldt, 1951, found it to be 39 days for one female of an European squirrel reared in captivity. The suckling period in the nest is another 45-day period. Thus the animals are usually about two months old before they can first be spotted on the ground. At the first breeding period after their birth they are quite immature but by the time of the second mating period are mature enough to participate in sexual play among themselves. They mature fully between this and the third mating periods. It may be precisely these individuals which are largely responsible for the interseasonal activity from March to May and again from November to the winter activity period.

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Quantum Theory and Psychotherapy

ELIZABETH Z. JOHNSON, VA Hospital, Lexington, Ky.

Quantum theory, originating in physics in 1900, has been recognized in chemistry, biology, and, lately, in psychology. Quantum principles should also be relevant to personality theory and psychotherapy.

Quantum deals with discontinuous "changes of state" in stable molecular configurations. Reconfigurations (e.g., mutations) are "quantum jumps": (1) they take place only over intermediate configurations requiring *higher* energy levels than the final state; (2) they occur, rarely, when heat-energy accumulates beyond that generally dissipated in wave phenomena or resonance; (3) they are single localized events, initiating what Langmuir calls "divergency phenomena—the effect of a single quantum transition becoming magnified throughout the bounding matrix, so that the behavior of the aggregate is altered from convergent expectations." London says an idea is a "divergency" and that insight is the "end process" of a series of fluctuations (resonances) eventuating in "restructure of the whole . . . which can involve the total personality, as in religious conversion."

Alexander and French use "conversion" as one criterion of successful psychotherapy. Mowrer has pointed out "discontinuity" between attitudes of neurotic and normal people. (Cf. Kirkegaard's "leap".) Social learning illustrates a "divergent phenomenon"; acculturation itself, the incorporation of social authority and expectations, represents the reconfiguration of a changed state in personality.

A crucial question is why some people fail to attain these requisite levels and thus require hospital treatment; and what should this treatment be? Quantum theory suggests that insufficient energy was originally available for the "quantum leap"—insufficient "love" to achieve the crucial identification with authority—which demands more effort than is apparent, since *higher* levels of energy must be attained than are stabilized in the final state. Psychotherapy ideally should supply: (1) a matrix of "loving authority", to encourage identification —i.e., the therapeutic climate of a good mental hospital; (2) "resonance" affects in many individually rewarding experiences; and (3) introduction of "divergency expectations" in directive interpretations. Psychotherapy should focus on consolidation of the "quantum leap" to which patients often attain in advance of insight.

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CHANGE OF INDEPENDENT VARIABLE IN DIFFERENTIAL EQUATIONS

S. WEIHE and T. J. PIGNANI
Department of Mathematics and Astronomy
University of Kentucky, Lexington, Kentucky

When attempting to solve a differential equation which is not solvable by elementary methods much time is wasted in either trying to guess at a solution of the equation in question or to search the literature for material which may throw some light on the solution of this equation. One approach, which if not loverlooked it is given an unfair trial, is to make a change in variable to reduce the equation to one of familiar form—see (Rainville 1951) in the case of the second order linear differential equation. This approach involves just three possibilities; these are to change the dependent variable, to change the independent variable, or to change the dependent and independent variable. Furthermore, efforts can be organized and observations of these results may lead to definite information about the differential equation in question.

In a recent unpublished study (by Wiehe) ordinary linear differentian equations of the third and fourth order with general variable coefficients were transformed to differential equations whose solutions are known, as given in Kamke (1948), by making a change of independent variable alone. The results of this investigation are too lengthy and too detailed to reproduce herein. In summary, the interesting fact was that in many cases the conditions to be imposed on the coefficients of the given differential equation to affect such a transformation were not severe.

To illustrate the procedure that was used by Weihe, the third order linear differential equation, namely

$$(1)\quad L(y) \equiv y''' + p(x)y'' + q(x)y' + r(x)y = 0$$

is considered, where $r(x) \neq 0$ and primes denote differentiation with respect to the independent variable x. In particular, the problem on hand is to determine the conditions placed on the coefficients of (1) so that a transformation of independent variable will produce a differential equation which in particular has constant coefficients. Stated formally, *Theorem.* Necessary and sufficient conditions that (1) be transformed to an equation with constant coefficients by a change of independent variable are that the expressions

(A) $\left[\frac{r'}{r} + p\right] r^{-\frac{1}{3}}$

and

(B) $\left[\frac{r''}{r} - \frac{2}{3}\left(\frac{r'}{r}\right)^2 + \frac{pr'}{r} + 3q\right] r^{-\frac{2}{3}}$

be constants.

Proof: Under a change of independent variable from x to z, the derivatives take the following forms

$$y' = z'\dot{y}, \quad y'' = z''\dot{y} + (z')^2\ddot{y}, \text{ and}$$

$$y''' = z'''\dot{y} + 3z'z''\ddot{y} + (z')^3\dddot{y}$$

where dots indicate differentiation with respect to the new independent variable z. With these results, equation (1) becomes

$$(2) \quad (z'')^3\dddot{y} + [3z'z'' + p(z'')^2]\ddot{y} + k\dot{y} + ry = 0,$$

where $k = L(z) - rz$; alternately with $r = 0$, follows that

$$(3) \quad \frac{(z')^3}{r}\dddot{y} + \frac{1}{r}[3z'z'' + p(z')^2]\ddot{y} + \frac{k}{r}\dot{y} + y = 0.$$

Necessity: If equation (3) is assumed to have constant coecfficients, then

$$(4) \quad \frac{(z')^3}{r} \equiv c^3$$

$$(5) \quad \frac{1}{r}[3z'z'' + p(z')^2] \equiv a,$$

$$(6) \quad \frac{k}{r} \equiv b,$$

where c, a, and b are constants.

Expression (4) is rewritten as

$$(7) \quad z' = cr^{\frac{1}{3}}$$

which by differentiation takes the forms

$$(8) \quad z'' = \frac{c}{3}r'r^{-\frac{2}{3}}$$

and by integration as

$$(10) \quad z = c\int r^{\frac{1}{3}}\,dx\,.$$

The substitution of (7), (8), (9), and (10) in (5) and (6) yield that

$$(9) \quad z''' = \frac{c}{3}\left[\, r''\, r^{-\frac{2}{3}} - \frac{2}{3}(r')^2 r^{-\frac{5}{3}} \,\right],$$

$$\frac{1}{r}\left[\, 3z'z'' + p(z')^2 \,\right] \equiv c^2\left[\frac{r'}{r} + p\right] r^{-\frac{1}{3}}$$

and

$$\frac{k}{r} \equiv \frac{c}{3}\left[\frac{r''}{r} - \frac{2}{3}\left(\frac{r'}{r}\right)^2 + \frac{pr'}{r} + 3q\right] r^{-\frac{2}{3}}$$

The members on the left are assumed to be constants by hypothesis, hence the members on the right are constants, but for except a constant factor, these are expressions (A) and (B), constants as required. *Sufficiency:* Through the use of (10), the change of the independent variable transforms (3) to

$$c^3\dddot{y} + c^2\left[\frac{r'}{r} + p\right] r^{-\frac{1}{3}}\ddot{y} + \frac{c}{3}\left[\frac{r''}{r} - \frac{2}{3}\left(\frac{r'}{r}\right) + \frac{pr'}{r} + 3q\right]\dot{y} + y = 0\,,$$

From this equation the fact that the reduction of (A) and (B) to be constants is sufficient to insure that the resultant equation has constant coefficients under the suggested change of independent variable given by (10).

To serve as an application of the above theory and also to unveil a mystery which appears in most first courses in differential equations, the classical *Euler Equation* is now considered. For convenience the following form of this equation is chosen,

$$(11) \quad y''' + f(ax + b)^{-1}y'' + g(ax + b)^{-2}y' + h(ax + b)^{-3}y = 0\,,$$

where a, b, f, g, and h are constants such that $ax + b = 0$ and $h = 0$. In this case expression (A) becomes

$$(f - 3a)h^{-\frac{1}{3}}$$

and (B) reduces to

$$3[2a^2 - af + g]h^{-\frac{2}{3}}$$

each being a constant as required. The transformation which reduces (11) to an equation with constant coefficients is obtained from (10) to be

$$z = ch^{\frac{1}{3}} \int \frac{dx}{ax + b}$$

$$= m \log_e (ax + b) \quad \text{where } m = (ch^{\frac{1}{3}}) / a \ .$$

With the choice of $m = a = 1$ and $b = 0$ equation (11) becomes the simplest *Euler Equation* along with its transformation $x = e^z$ usually studied in a first course in differential equations.

Theorems similar to the one given above could be developed for differential equations of higher order.

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ACADEMY AFFAIRS

1961 Spring Meeting

The 1961 spring meeting of the Academy was held at Morehead State College, Morehead, Kentucky, on May 6, 1961. The program follows.

8:30-9:15 a.m.—Registration, Lobby of Lappin Hall.

9:20-9:30 a.m.—Orientation for Field Trips—Room 105, Lappin Hall.

FIELD TRIPS

9:30-12:00 a.m.—Bird Hike—Leader, Mr. Toney Phillips.

10:00-12:00 a.m.—Visit to A.E.C. Project on Irradiation of Seeds of Native Tree Species (with illustrated explanation)—Dr. Margaret B. Heaslip.

9:30 a.m.-4:00 p.m.—Geology trip of the Morehead Region. Leaders: Dr. James E. Conkin and Mr. Jackson A. Taylor. Items of interest: Lee Clay Products, Clack Mountain, Lockegee, Eastern Kentucky Peneplain, Farmers Glacial Erratic, Knob Licks, Blue Stone Quarry. Field trip covers the Paleozoic from Silurian to Pennsylvanian plus the Pleistocene—a 350,000 year span.

1:00-4:00 p.m.—Wild Flower Walk—Leader, Dr. Mary E. Wharton.

1:00-4:00 p.m.—Amphibian and Reptile Hike—Leader, Dr. Roger Barbour.
If a sufficient number should be interested, a trip to Bat Cave, of the Carter Caves Region, will be planned for Sunday morning, May 7. If you are interested, please check the appropriate place on the dinner reservation so that arrangements can be made in advance for the trip.

Lunch,

12:00-1:00 p.m.—No special arrangements will be made for lunch. Lunch may be had at the cafeteria in Doran Student House or at downtown restaurants. Those going on the all day geology trip should plan to take lunch to eat at Lockegee.

4:00-5:00 p.m.—Slide Viewing. Audio-Visual Room of Doran Student House. "Views of Interest of the Morehead Region". Mr. Allen Lake.

5:00-6:00 p.m.—Social Hour—Faculty Lounge, Doran Student House.

6:00 p.m.—Dinner—Dining room of Doran Student House. Dr. Loren D. Carlson, Chairman and Professor, College of Medicine, University of Kentucky, will be the after dinner speaker, with the topic "Physiology and Space Flight".

1961 Fall Meeting

The 1961 fall meeting will be held at the University of Kentucky, Lexington, Kentucky.

MEMBERSHIP LIST — KENTUCKY ACADEMY OF SCIENCE

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MR. CHESTER A. ALEXANDER, Georgetown College, Georgetown, Ky.
MR. LLOYD E. ALEXANDER, Kentucky State College, Frankfort, Ky.
SISTER ALICE MARIA GOODE, Nazareth College, 851 South 4th Street, Louisville, Ky.
LUCIA ANDERSON, Biology Department, Western Kentucky State College, Bowling Green, Ky.
SISTER ANGELICE SEIBERT, Ursuline College, Louisville, Ky.
DR. J. W. ARCHDEACON, Dept. of Anatomy and Physiology, University of Kentucky, Lexington, Ky.
MR. WILLIAM B. ATKINSON, Dept. Of Anatomy, University of Louisville Louisville, Ky.
WILLIAM O. ATKINSON, Agronomy Dept., University of Kentucky, Lexington, Ky.
DR. MERL BAKER, Dept. of Mechanical Engineering, University of Kentucky, Lexington, Ky.
ALBERT BALOWS, Lexington Clinic, Harrodsburg Rd., Lexington, Ky.
S. B. BANDEEN, 3617 Lexington Rd., Louisville, Ky.
DR. ROGER W. BAROUR, Dept. of Zoology, University of Kentucky, Lexington, Ky.
WILLIAM BYRD BARKLEY, 234 W. Third Street, Maysville, Ky.
THOMAS R. BEBEE, College Box 20, Berea, Ky.
JOHN J. BEGIN, Poultry Dept., University of Kentucky, Lexington, Ky.
ROBERT P. BELILES, 3515 Nanz Ave., Low, Ky.
DR. D. M. BENNETT, Dept. of Physics, University of Louisville, Louisville, Ky.
DR. HARLOW BISHOP, Lederle Laboratories, Pearl River, N. Y.
RAY H. BIXLER, Psychology Dept., University of Louisville, Louisville, Ky.
DR. J. G. BLACK, Eastern Kentucky State College, Richmond, Ky.
MR. RODNEY E. BLACK, Chemistry Dept., University of Kentucky, Lexington, y.
DR. W. E. BLACKBURN, Murray State College, Murray, Ky.
FRED BOERCHER, Western Kentucky State College, Bowling Green, Ky.
REV. CHESTER B. BOWLING, 1801 Harvard Drive, Louisville, Ky.
REV. JOSEPH R. BOWLING, Bellarmine College, Louisville, Ky.
LOUIS L. BOYARSKY, Anatomy and Physiology Dept., University of Kentucky, Lexington, Ky.
MISS RUTH BOYDEN, College of Agriculture, University of Kentucky, Lexington, Ky.
MR. ROBERT M. BOYER, Dept. of Chemistry, University of Kentucky, Lexington, Ky.
MRS. JOHN BRAKE, 150 Oakland Park Ave., Columbus, O.
ELLIS V. BROWN, Chemistry Dept., University of Kentucky, Lexington, Ky.
JAMES B. BROWN, Kentucky State College, Frankfort, Ky.
WILLIAM K. BROWN JR., Engineering, 915 McClain Drive, Lexington, Ky.
EDWARD T. BROWNE JR., Botany Dept., University of Kentucky, Lexington, Ky.
ROBERT R. BRYDEN, Biology Dept., High Point College, High Point, N. C.
WILBUR G. BURROUGHS, Box 1008, Chautauqua, N. Y.
PAUL CALLAHAN, Biochem. Dept., Medical School, University of California, San Francisco, Calif.
JAMES S. CALVIN, Dept. of Psychology, University of Kentucky, Lexington, Ky.

PROF. A. G. CANON, Physical Science Dept., Murray State College, Murray, Ky.
WILLIAM F. CANTRELL, 9909 Dickens, Bethesda, Md.
PROF. JULIAN H. CAPPS, Berea College, Berea, Ky.
DR. JOHN M. CARPENTER, Dept. of Zoology, University of Kentucky, Lexington, Ky.
MISS VADA CHUMLEY, 1601 Exeter Ave., Middlesboro, Ky.
GENEVIEVE CLARK, Georgetown College, Georgetown, Ky.
MARY BENEDICT CLARK, 301 McCready Ave., Louisville, Ky.
DR. WILLIAM M. CLAY, Dept. of Biology, University of Louisville, Louisville, Ky.
ARCH E. COLE, 101 W. Chestnut St., Louisville, Ky.
EVELYN COLE, Murray State College, Murray, Ky.
DR. GERALD A. COLE, Division of Life Science, Arizona State College, Tempe, Ariz.
BARBARA M. CONKIN, Geology Dept., University of Louisville, Louisville, Ky.
JAMES E. CONKIN, Geology Dept., University of Louisville, Louisville, Ky.
ELLIS R. CARTER, Dept. of Fish and Wildlife Resources, Frankfort, Ky.
MISS LAURINE CAVE, Box 5437 University Station, Lexington, Ky.
RICHARD A. CHAPMAN, Dept. of Agronomy, University of Kentucky, Lexington, Ky.
JAMES R. CHARLES, Capital Heights, Frankfort, Ky.
MISS NELL SUE CHEATHAM, Morehead State College, Morehead, Ky.
JOHN A. CHEEK, Lambeth College, Jackson, Tenn.
DR. PAUL CHRISTIAN, Dept. of Biology, University of Louisville, Louisville, Ky.
MAURICE CHRISTOPHER, Chemistry Dept., Murray State College, Murray, Ky.
CARL COOK, Crailhope, Ky.
E. WILBUR COOK, Box 42 Centre College, Danville, Ky.
DR. CLARA C. COOPER, Berea College, Berea, Ky.
C. S. CROUSE, Engineering College, University of Kentucky, Lexington, Ky.
ANNE P. CUNNINGHAM, 737 South Limestone, Lexington, Ky.
URSULA MARCH DAVIDSON, Carrie, Ky.
DR. P. A. DAVIES, Dept. of Biology, University of Louisville, Louisville, Ky.
TYRUS R. DAVIS, Banker's Bond Company, Kentucky Home Life Bildg., Louisville, Ky.
DR. LYLE R. DAWSON, Dept. of Chemistry, University of Kentucky, Lexington, Ky.
MR. FRANKLIN DAY, Pikeville College, Pikeville, Ky.
DR. STEPHEN DIACHUN, Ky. Agricultural Experiment Station, Lexington, Ky.
MISS MARY L. DIDLAKE, 248 Market Street, Lexington, Ky.
GRAHAM B. DIMMICK, B-202 Shawneetown, Lexington, Ky.
DONALD A. DISTLER, Dyche Hall, University of Kansas, Lawrence, Kan.
MR. WILLIAM L. DIXON, Kentucky State College, Frankfort, Ky.
JOHN W. DONAHUE, Psychology Dept., University of Kentucky, Lexington, Ky.
RICHARD F. DOOLEY, Kentucky Reptile Garden, Park City, Ky.
R. M. DOUGHTY, College of Pharmacy, University of Kentucky, Lexington, Ky.
WILLIAM G. DOWNS, JR., 212-E-6W, Cookeville, Tenn.
G. LUTHER DRAFFEN, Calvert City, Ky.
W. G. DUNCAN, 325 Glendover Road, Lexington, Ky.
J. C. EAVES, Dept. of Math. and Astronomy, University of Kentucky, Lexington, Ky.
HARTLEY C. ECKSTROM, Chemistry Dept., University of Kentucky, Lexington, Ky.
DR. O. F. EDWARDS, Dept. of Bacteriology, University of Kentucky, Lexington, Ky.
DR. WILLIAM D. EHMANN, Dept. of Chemistry, University of Kentucky, Lexington, Ky.

A. E. ELKAYER, Mech. Engineering Dept., Auburn University, Auburn, Ala.
JAMES McCLELLAND ELLIOTT, Dept. Mech. Engineering, University of Kentucky, Lexington, Ky.
DR. STATIE ERICKSON, Dept. of Home Economics, University of Kentucky, Lexington, Ky.
DR. R. C. ERNST, University of Louisville, Speed Scientific School, Louisville, Ky.
CARL F. ESSIG, 1455 Forbes Road, Lexington, Ky.
DR. BETSEY WORTH ESTES, Neville Hall, University of Kentucky, Lexington, Ky.
LOUIS M. EYERMANN, Box 13 Station E., Louisville, Ky.
HAROLD H. FENWICK, University of Louisville, Louisville, Ky.
DR. E. N. FERGUS, Ky. Agricultural Experiment Station, Lexington, Ky.
DR. T. E. FIELD, 1554 Cardinal Drive, Louisville, Ky.
HAROLD G. FLANARY, Addiction Research Center, Public Health Service, Lexington, Ky.
RALPH FORNEY, 305 Horton St., Columbia, Ky.
ARTHUR W. FORT, Dept. of Chemistry, University of Kentucky, Lexington, Ky.
MR. J. F. FREEMAN, Ky. Agricultural Experiment Station, Lexington, Ky.
DR. WILLIAM F. FURNISH, Biology Dept., University of Louisville, Louisville, Ky.
FRANKLIN B. GAILEY, Berea College, Berea, Ky.
LARRY R. GALE, 1204 Winston Drive, Jefferson City, Mo.
JASPER H. B. GARNER, Botany Dept., University of Kentucky, Lexington, Ky.
LEE W. GILDART, Dept. of Physics, University of Kentucky, Lexington, Ky.
SETH GILKERSON, Berea College, Berea, Ky.
DR. L. C. GLENN, Geology Dept. Vanderbilt University, Nashville, Tenn.
PROF. R. E. GOODGION, Murray Training School, Murray State College, Murray, Ky.
MISS ELVA GOODHUE, Lindsey Wilson Junior College, Columbia, Ky.
JOHN D. GOODLETTE, 2338 Howard Drive, Orlando, Fla.
DR. R. B. GRIFFITH, 2104 Strathmoor Blvd., Louisville, Ky.
RICHARD M. GRIFFITH, Clinical Psychology, Veterans Hospital, Lexington, Ky.
MR. JAMES GROSSMAN, Foundation School, Berea College, Berea, Ky.
MR. CHARLES R. GUNN, Ross Seed Company, P.O. Box 1712, Louisville, Ky.
CHARLES S. GUTHRIE, Burkesville, Ky.
MR. ROBERT L. HADLEY, 201 Ashland Road, Louisville, Ky.
DR. HANS HAHN, Psychology Dept., Transylvania College, Lexington, Ky.
EDMOND K. HALL, School of Medicine, University of Louisville, Louisville, Ky.
C. B. HAMANN, Asbury College, Wilmore, Ky.
PROF. E. M. HAMMAKER, Dept. of Chemistry, University of Kentucky, Lexington, Ky.
RAYMOND E. HAMPTON, Agronomy Dept., University of Kentucky, Lexington, Ky.
MR. HUNTER M. HANCOCK, 1107 Elm Street Ext., Murray, Ky.
JOSEPH E. HANEGAN, Biology Dept., Bellarmine College, Louisville, Ky.
FANNIE R. HARMON, Sue Bennett College, London, Ky.
ALTON M. HARVILL JR., Biology Dept., Murray State College, Murray, Ky.
DR. MARGARET B. HEASLIP, Morehead State College, Morehead, Ky.
CARLTON HECKROTTE, Biology Dept., Eastern Kentucky State College, Richmond, Ky.
GEORGE H. HEMBREE, 58 Salem Lane, Little Silver, N. J.
JAMES P. HENLEY, Dept. of Fish and Wildlife, Division of Fisheries, Frankfort, Ky.
DR. CARL E. HENRICKSON, Dept. of Botany, University of Kentucky, Lexington, Ky.

J. EDWARDO HERNANDEZ, Romance Languages Dept., University of Kentucky, Lexington, Ky.
DR. THOMAS C. HERNDON, Eastern Kentucky State College, Richmond, Ky.
DONALD G. HICKS, Chemistry Dept., College Box 1167, Murray, Ky.
HARRIS E. HILL, Nat. Inst. of Mental Health, Public Health Service, Lexington, Ky.
FREDERICK K. HILLE, 410 Rose Lane, Lexington, Ky.
MISS ANNA L. HOFFMAN, 8 Ft. Mitchell Avenue, Ft. Mitchell, Ky.
ANTHONY A. HOHNHORST, 3010 Dixie Highway, Covington, Ky.
DR. J. P. HOLT, University of Louisville, 101 West Chestnut Street, Louisville, Ky.
HOWARD HOPKINS, Pharmacy Dept., University of Kentucky, Lexington, Ky.
ARLAND HOTCHKISS, Dept. of Biology, University of Louisville, Louisville, Ky.
DR. MARGARET HOTCHKISS, Dept. of Bacteriology, University of Kentucky, Lexington, Ky.
MR. JOHN HOUCHENS, Registrar, University of Louisville, Louisville, Ky.
H. L. HULL, Box 723, Berea College, Berea, Ky.
DR. JAMES C. HUMPHRIES, Bacteriology Dept., University of Kentucky, Lexington, Ky.
KARL F. HUSSUNG, Chemistry Dept., Murray State College, Murray, Ky.
MR. W. M. INSKO, Ky. Agricultural Experiment Station, University of Kentucky, Lexington, y.
CHARLES JOSEPH ISBELL, Botany Dept., University of Kentucky, Lexington, Ky.
CRAYTON T. JACKSON, Morehead State College, Morehead, Ky.
DANIEL F. JACKSON, Biology Dept., University of Louisville, Louisville, Ky.
E. M. JOHNSON, Agronomy Dept., University of Kentucky, Lexington, Ky.
ELIZABETH Z. JOHNSON, Vet. Admin. Hospital, Lexington, Ky.
DR. SYDNEY E. JOHNSON, St. Joseph Infirmary, Louisville, Ky.
THOMAS H. JOHNSON, Poultry Dept., University of Kentucky, Lexington, Ky.
FRANCIS J. JOHNSTON, Chemistry Dept., University of Georgia, Athens, Ga.
ERNST JOKL, Physiology Dept., University of Kentucky, Lexington, Ky.
DAN JONES, Miller Hall, University of Kentucky, Lexington, Ky.
P. R. JONES, Cumberland College, Williamsburg, Ky.
ARNOLD J. KAHN, Biology Dept., Columbia University, New York, N. Y.
THOMAS E. KARGL, Chemistry Dept., Ursuline College, Louisville, Ky.
PROF. P. E. KARRAKER, Ky. Agricultural Experiment Station, Lexington, Ky.
DR. J. A. KENNEDY, 101 W. Chestnut Street, Louisville, Ky.
CHARLES KEYS, Robert Wesleyan College, North Chili, N. Y.
FRANK KODMAN, Psychology Dept., University of Kentucky, Lexington, Ky.
EMIL KOTCHER, 101 West Chestnut Street, Louisville, Ky.
L. A. KRUMHOLZ, Biology Dept., University of Louisville, Louisville, Ky.
ROBERT A. KUEHNE, Zoology Dept., University of Kentucky, Lexington, Ky.
JAMES F. LAFFERTY, General Engineering Dept., University of Kentucky, Lexington, Ky.
PROF. H. H. LAFUZE, Eastern State College, Richmond, Ky.
ALLEN L. LAKE, College Box 782, Morehead, Ky.
DR. L. Y. LANCASTER, 930 Nutwood, Bowling Green, Ky.
DR. KARL O. LANGE, Aeronautical Research Lab., University of Kentucky, Lexington, Ky.
ROBERT LARANCE, Eastern Kentucky State College, Richmond, Ky.
JAMES K. LATHAM, 533 So. Limestone St., Lexington, Ky.
J. TRAVIS LEACH, 6995 Beechland Ave., Pleasure Ridge Park, Ky.
WILLIAM M. LEACH, 1005 N. Broadway Avenue, Knoxville, Tenn.
JOAN C. LEE, Psychology Dept., University of Kentucky, Lexington, Ky.
JOHN J. LEHRBERGER, 705 S. Mason St., Harrisonburg, Va.
ROY C. LESTER, Morehead State College, Morehead, Ky.

GERRIT LEVEY, Berea College, Berea, Ky.
DWIGHT M. LINDSAY, Georgetown College, Georgetown, Ky.
DR. HARVEY B. LOVELL, Biology Dept., University of Louisville, Louisville, Ky.
ETHEL W. LOVELL, 2424 Dundee Rd., Louisville, Ky.
BEN H. LYND, Morehead State College, Morehead, Ky.
DR. JAMES T. McCLELLAN, 506 Spring Hill Drive, Lexington, Ky.
DR. A. C. McFARLAN, Geology Dept., University of Kentucky, Lexington, Ky.
PRESTON McGRAIN, Kentucky Geological Survey, University of Kentucky, Lexington, Ky.
EVANS C. McGRAW, 684 Loudon Avenue, Lexington, Ky.
DONALD W. MACLAURY, Ky. Agricultural Experiment Station, Lexington, Ky.
PAUL R. McNEELY, Psychology Dept., Asbury College, Wilmore, Ky.
MR. MAURICE K. MARSHALL, Dept. of Mechanical Engineering, University of Kentucky, Lexington, Ky.
WILLIAM R. MARTIN, 1753 Blue Licks Road, Lexington, Ky.
HARRY LOUIS MASON, Dept. Mech. Engineering, University of Kentucky, Lexington, Ky.
MR. HAL W. MAYNOR, Dept. of Mechanical Engineering, Alabama Polytechnic Institute, Auburn, Ala.
MRS. E. E. MAYO, Science and Math Dept., Morehead State College, Morehead, Ky.
SISTER M. CONCETTA, Ursuline College, Louisville, Ky.
SISTER M. ANTONIA KLAPHEKE, St. Joseph Infirmary, Louisville, Ky.
SISTER MARY ADELINE, Nazareth College, Louisville, Ky.
HARRY LOUIS MASON, Dept. of Mechanical Engineering, University of Kentucky, Lexington, Ky.
JACOB MEADOW, Chemistry Dept., University of Kentucky, Lexington, Ky.
J. P. MILES, JR., 2737 Daviess St., Owensboro, Ky.
MRS. MILDRED MILES, 2737 Daviess St., Owensboro, Ky.
LOUISE B. MILLER, Psychology Dept., University of Louisville, Louisville, Ky.
JOSEPH G. MONTGOMERY, Chairman, Science Dept., Manatee Junior College, Bayshore Gardens, Bradenton, Fla.
DR. WALTER L. MOORE, Dept. of Mathematics, University of Louisville, Louisville, Ky.
DEAN WILLIAM J. MOORE, Eastern Kentucky State College, Richmond, Ky.
DR. F. B. MOOSNICK, 184 North Mill Street, Lexington, Ky.
MONROE MOOSNICK, Versailles, Ky.
MISS MARGARET MORTON, 340 Columbia Avenue, Lexington, Ky.
KENNETH N. MUSE, 2320 N. Main., Findlay, Ohio
DR. VINCENT E. NELSON, Dept. of Geology, University of Kentucky, Lexington, Ky.
RICHARD NEWCOMER, Zoology Dept., University of Kentucky, Lexington, Ky.
MISS HAZEL NOLLAU, 500 College Avenue, Morehead, Ky.
WILLIAM NORRIS, Western Kentucky State College, Bowling Green, Ky.
THOMAS G. NYE, Botany Dept., University of Kentucky, Lexington, Ky.
VICTOR G. OSBORNE, 343 East College Street, Georgetown, Ky.
WILLIAM OWENS, Western Kentucky State College, Bowling Green, Ky.
DR. WILLIAM B. OWSLEY, Morehead State College, Morehead, Ky.
MR. GEORGE H. PAINE, JR., 446 Ludlow Highway, Ludlow, Ky.
PETE PANZERA, Murray State College, Murray, Ky.
SUSIE ANA PARKER, Harlan County Schools, Loyall, Ky.
JOHN M. PATTERSON, Dept. of Chemistry, University of Kentucky, Lexington, Ky.
SIGFRED PETERSON, 332 East Fairview Road, Oak Ridge, Tenn.
MISS MARY PETTUS, Union College, Barbourville, Ky.
MRS. HELEN J. PFOHL, 4412 Taylor Blvd., Louisville, Ky.

JOHN C. PHILLEY, Morehead State College, Morehead, Ky.
DR. J. P. PHILLIPS, Chemistry Dept., University of Louisville, Louisville, Ky.
TONEY PHILLIPS, Morehead State College, Morehead, Ky.
TULLIO J. PIGNANI, Mathematics Dept., University of Kentucky, Lexington, Ky
H. C. PIRKLE, Rt. 1 Box 505, Anchorage, Ky.
WILLIAM K. PLUCKNETT, Dept. of Chemistry, University of Kentucky, Lexington, Ky.
JUDITH D. PRATT, 234 Reed Lane, Lexington, Ky.
HUGH PUCKETT, Allen County High School, Scottsville, Ky.
WILLIAM T. QUERY, Veterans Administration Hospital, Lexington, Ky.
WILLIAM G. READ, Murray State College, Murray, Ky.
CHARLES REIDLINGER, Biology Dept., Murray State College, Murray, Ky.
R. B. RENDA, Mech. Eng. Dept., University of Kentucky, Lexington, Ky.
GERTRUDE C. RIDGEL, Biology Dept., Kentucky State College, Frankfort, Ky.
J. W. RIDGWAY, 5300 Alpine Way, Louisville, Ky.
DR. H. P. RILEY, Botany Dept., University of Kentucky, Lexington, Ky.
DR. EARLAND RITCHIE, Centre College, Danville, Ky.
THOMAS G. ROBERTS, Geology Dept., University of Kentucky, Lexington, Ky.
SISTER RODERICK, Nazareth College, Louisville, Ky.
DR. J. G. RODRIGUEZ, Dept. of Entomology and Botany, Ky. Agricultural Experiment Station, Lexington, Ky.
AARON A. ROSEN, 2667 Cedarbrook Avenue, Cincinnati, Ohio
W. GORDON ROSS, Berea College, Berea, Ky.
R. I. RUSH, Chemistry Dept., Centre College, Danville, Ky.
MRS. ELLEN A. SANDERS, 620 W. Main St., Campbellsville, Ky.
R. J. SCALF, Joseph E. Seagram & Sons, Louisville, Ky.
DR. MORRIS SCHERAGO, Bacteriology Dept., University of Kentucky, Lexington, Ky.
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THE KIRTLEY SITE

A Mississippian Village in McLean County, Kentucky

M. A. ROLINGSON
Department of Anthropology, University of Kentucky, Lexington

Introduction

During the 1930's extensive archaeological excavations were undertaken in Kentucky through the auspices of the Works Progress Administration. Numerous prehistoric sites were excavated and the artifacts catalogued by WPA crews but sufficient personnel was not available to analyze and report on all of the material. This paper is aimed at reducing the backlog of unpublished sites by reporting on the Kirtley site, a small Mississippian village in southeastern McLean County. The main objectives are to describe the features and artifacts recovered from the Kirtley village; tentatively establish its chronological position within the prehistory of the area, relate it to other Mississippian sites in the state, and to draw some other conclusions from this information.

Geology

McLean County is centrally located in the Kentucky Western Coal Fields which are the southeastern portion of the Eastern Interior Coal Field extending northward into southern Indiana and Illinois. The general surface is gently rolling to hilly uplands dissected by streams which have flat swampy bottomlands with deposits of Pleistocene and Recent sand, gravel and silt (Burroughs, 1924 :1-19). The county is bisected by the Green River and bordered on the west by the Pond River and on the East by the Green and Rough Rivers.

Soils in the area include yellow silt loam from sandstone and sandy shales, bright yellow clay subsoil and gray or yellowish silt loam in the bottomlands (Burroughs, 1924 : 29-32).

Location of Site

The Kirtley site was located in the southeastern section of McLean County (see Figures 1 and 2) on the farm of Mr. Henderson Kirtley and his son, John Kirtley, one and one-half miles west of Island, Kentucky. This area is one of rolling to hilly ridges separated by the Green River and Cypress Creek. McL 19 is located on the western edge of one of these ridges, overlooking Cypress Creek to the west and south. The junction of the Green and Rough Rivers is three and one half miles to the north-northeast. The ridge on which the site is located is four hundred eighty feet above sea level, while the surrounding bottomlands are at an elevation of three hundred eighty feet.

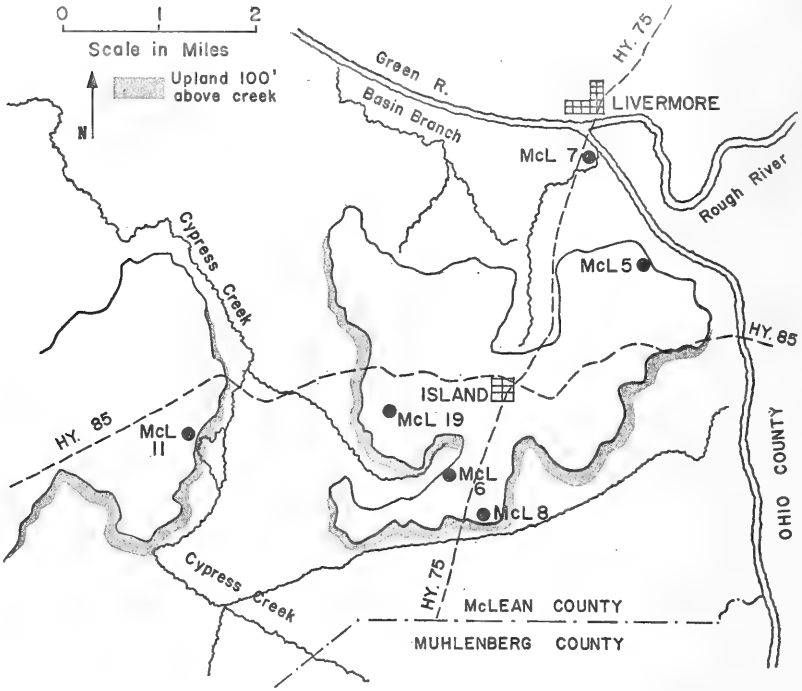

Fig. 1.—Detail map of region surrounding the Kirtley site, McL 19.

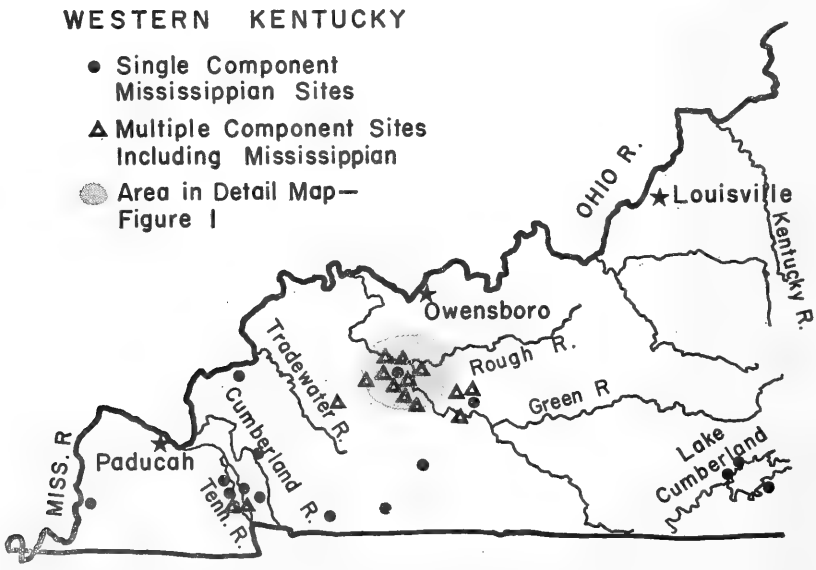

Fig. 2.—Map of western Kentucky locating single component Mississippian sites and multiple component sites with both Mississippian and earlier cultural manifestations.

Excavation Procedure

During the winter of 1937, excavations were being conducted at McL 6 (see Figure 1). At that time, test pits at McL 19 indicated a shallow midden which did not appear to warrant excavation. However, flood conditions in the spring of 1939 forced the abandonment of bottomland sites in western McLean County and Ohio County, so work was begun at McL 5, 7, and 19 (see Figure 1). Work began at McL 19 on March 18, 1939, with John B. Elliott as supervisor. Permission was granted for an excavation period of ten days, as the land was to be planted in pasture. When the extent of the site was realized, the period was extended to May 5. This relatively short time did not allow for complete excavation of all features, especially midden pits, but the extent of the village was defined and all house patterns were excavated.

In excavation the site was crossed by a preliminary north-south trench to sample midden, detect structures and record depth and extent of midden. From this preliminary trench, the site was staked in ten foot squares, oriented north-south. A datum level was established, but unfortunately its location was not recorded in the notes. The actual excavation consisted of shaving through the midden deposit with shovels until the yellow subsurface clay was exposed. As features were uncovered they were noted and outlined on the surface of the subsoil and the trenches of the house walls were then excavated vertically, as can be seen in Figure 4. The area of excavation measured 330 feet by 90 feet. As the midden, though extensive, was extremely superficial, averaging only .8 feet in depth, the main items of interest were the house patterns and midden pits.

House Patterns

The midden was so shallow that all house floors had been destroyed by cultivation and erosion; however, wall patterns indicated the presence of two house types. The predominant type, with thirteen houses, was constructed by placing wall posts in trenches with house corners left open or with corner posts set directly into the ground. These trenches extended into the subsoil. In the second type, totaling two houses, the wall posts were set directly into the ground, extending into the subsoil. All houses were rectangular structures. The three southernmost house locations (Features 9, 7, and 13) had been used for the construction of a single house each (see Figure 3). The three northernmost house locations (Features 4-6, 3, and 2) had been used in the construction of four houses each. All houses except the four located in Features 2 and 9 were oriented with their long walls

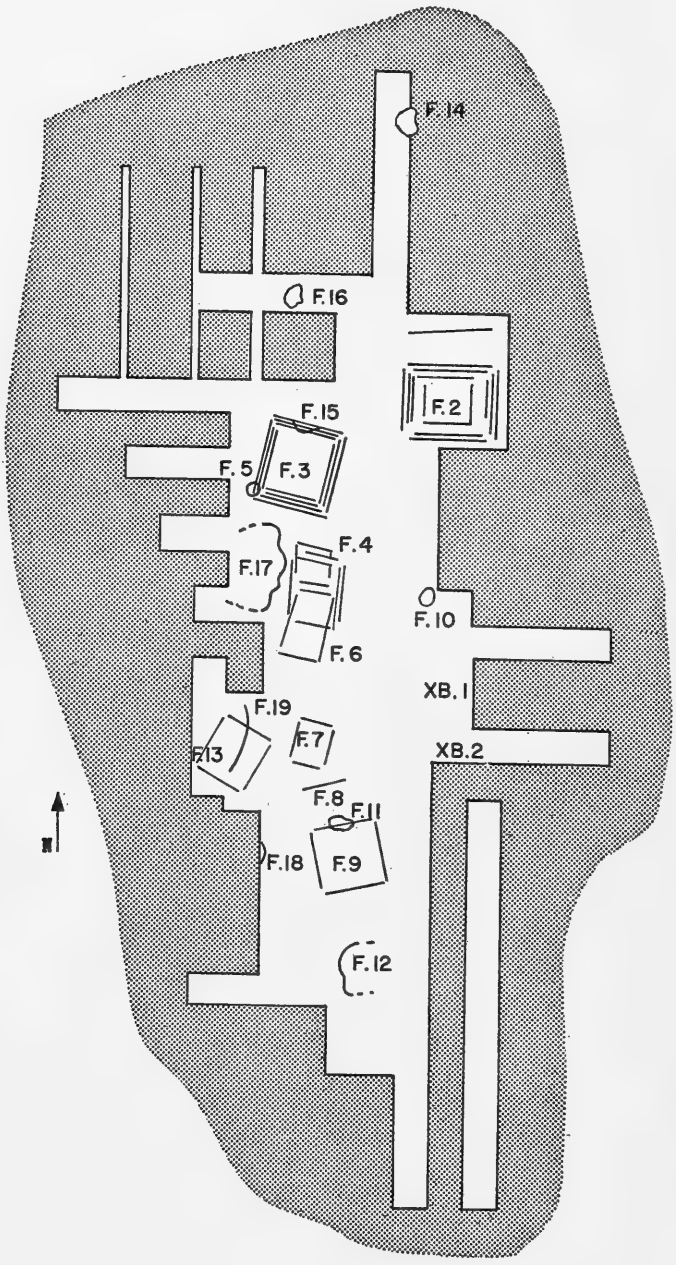

Fig. 3.—Kirtley site area of excavation locating features (F.) and burials (B.) Scale is approximately one inch to forty feet.

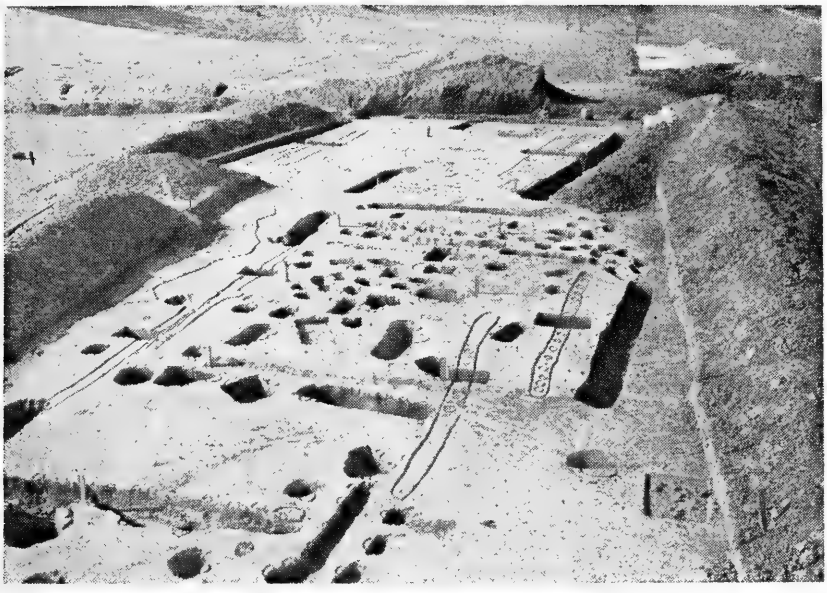

Fig. 4.—Excavation of the Kirtley site.

on a north-south or north northeast-south southwest line. Those in Features 2 and 9 were oriented east-west. Due to destruction of the site, all measurements were taken from the surface of the subsoil.

The two houses with posts set directly into the ground were centrally located in the village and are a part of Feature 4-6. Both are similar, except for size. House 4a measured 20 by 20.5 feet while house 4b measured 16 by 16.5 feet. Wall posts extended one foot into the subsoil and were rather small, ranging from .2 to .7 feet in diameter and averaged .4 feet. The west wall of house 4a could not be defined but is probably in the same location as the west wall of house 4. It cannot now be determined whether or not these two post wall houses were precedent to the two wall trench houses in the Feature.

Wall trench houses varied in size from 12 by 14 feet to 25.5 by 29.5 feet; however, twice as many had walls over twenty feet than were under twenty feet. The trenches for these walls ranged from 7.4 feet to 22.8 feet in length; from .4 feet to 1.4 feet in width and from .2 feet to 1.6 feet in depth. The number of posts within the trenches varied from twenty in house 6 to ninety-eight in house 3d. The diameter of the posts ranged from .2 feet to .7 feet, with an average of .3 feet. Seven of these houses had posts set in the ground at the corner; the maximum number of posts in one corner being three.

Two houses (13 and 4a) had partition walls extending out 4.4 and 5 feet from the west wall. These were located 5 feet down from the northwest corner of the houses. House 9 was the only one with possible indications of repair where more than one-third of the posts did not reach the floor of the trench, as they would have done had they been placed during the original construction. Time factors are apparent in only three instances. House 13 was built over a trench which apparently has no other association with any feature in the village. House 6 was built before house 4, as the south wall of house 4 crossed over the east wall of house 6. Houses 9 and 3 were built over midden pits.

Two factors suggesting house structure and time are present in the four houses of Feature 3. First, the depth of the trenches into the subsoil becomes shallower from the inside trenches to the outside trenches. Had a new house been constructed each time, the floor level of each would be raised by the debris of the old house, and a trench of equal depth would not have extended as far into the subsoil. Second, the inner trenches appear to be much more disturbed than the outer trenches which are clearly defined. Had the largest house been constructed first, it could be expected that there would be some destruction of the trenches of this house, with the inner trenches more clearly defined. Therefore, the earliest house was probably the smallest house and later houses were increasingly larger.

Discussion: Very few generalizations can be made about the Mississippian houses at the Kirtley village due to the destruction of the site; however, a few things appear to stand out and are worth noting. 1) The majority of the house posts touched the bottom or extended below the trench floor. 2) Only house 9 indicated that much repair had taken place, by the shallowness and interspersing of many of the postmolds. 3) Two houses had small interior partitions. 4) There was more house construction on the north end of the site. 5) Houses 3a, 3b and 9 postdate midden pits. 6) Houses 4a and 4b were of a different type construction than the rest of the village. 7) The builders of the houses in Features 2 and 3 must have had some knowledge of previous houses at that spot, because they are all oriented. This is not true of the houses in Feature 4-6. 8) There were no fireplaces within the houses.

Isolated Walls

Three isolated trenches located in the village do not appear to be associated with houses (see Figure 3). Two of these did not have postmolds in them and their use is conjectural. One was located five

feet south of house 7; the other was fifteen feet north of the houses in Feature 2. The third trench contained postmolds and is precedent to house 13. In addition to these isolated trenches, a row of postmolds was located one and a half feet north of house 9. This structure suggests some type of fence or pallisade, or a lean-to attached to the house.

Refuse Pits

The seven midden or refuse pits located in the village (Figure 3) can be separated into three types for purposes of discussion. Three large, shallow pits were not entirely excavated and defined due to lack of time; three were small, deep pits and one pit contained artifacts of historic origin.

The first type of midden pit was large, extending up to twenty-two feet in length, and shallow, reaching an interior depth of .8 feet. These were all located near houses and may have originally been dug to obtain clay for plastering the house walls and later used for refuse.

The second type of pit was small, not over ten feet in length, with an interior depth extending to two feet. Two of these, Features 15 and 11, were precedent to the houses in Features 3 and 9.

The seventh pit, Feature 14, was located sixty feet north of the main village area. It contained refuse of historic origin including a broken dish, glass fragments, sheet tin, half of a bone handle from a modern knife or fork, and artifacts of possible Indian origin including a small, smooth sandstone ball, a smooth, triangular piece of sandstone, and two lumps of clay, one coated with a lime wash. This refuse pit may not be the same age as the rest of the village.

Areas of Irregular Rocks

Feature 5 was an area 3.5 by 3.0 feet of irregular sandstone rocks within the habitation level, over and therefore postdating the south end of the west wall of House 3c. It could have been placed during the use of house 3d or after the abandonment of the houses in Feature 3. It had a vertical thickness of .2 feet.

Feature 16 was an area of irregular sandstone and limestone rocks, 3.0 by 2.5 feet, in the habitation level of the site, thirty feet north of Feature 3. None of the rocks in these two areas appear to have been fired or burned and their use is conjectural.

Burials

Only two burials were located during excavation, both on the eastern side of the village area and relatively isolated from the houses (Figure 3). In Burial 1 there was no evidence of either a stone box

or a pit grave. The bone was poorly preserved; however, it appears to have been an extended, flesh burial of one adult, sex unknown. The head was oriented toward the west.

The second burial was a stone box grave which contained only one fragment of a child's rib. The stone box was oriented northwest-southeast and measured 2.5 by 1.0 feet. It contained a thin slab floor surrounded by a single upright slab on the northwest end, two upright slabs on the southeast end, and a single upright slab in the northeast wall. The southwest wall and roof had been destroyed by cultivation and were scattered in the grave and to the southwest. The box was made of sandstone rather than limestone as is more common in Mississippian burials, but the area in which the Kirtley village is located contains outcrops of Pennsylvanian sandstone.

Artifacts

A total of two hundred forty artifacts, other than pottery, was recovered from McL 19. The majority are chipped and ground stone artifacts, while bone and shell are relatively scarce, possibly due to soil acids. No depth distribution of the artifact types was possible because of the shallowness of the site. Table 1 lists the artifacts, total number present and percentage.

Table 1.—Artifacts from the Kirtley Site

Artifact	Number Present	Percentage of Total	Percentage of Type
Projectile points	83	34.58	
Side-notched	31		37.34
Triangular	16		19.27
Stemmed	11		13.37
Shallow side-notched	9		10.84
Corner-notched	6		7.10
Lanceolate	6		7.10
Serrated	1		1.20
Unclassified	3		3.61
Scrapers	62	25.83	
Bifacial			
Side-notched	25		40.32
Shallow side-notched	2		3.22
Stemmed	1		1.61
Corner-notched	3		4.83
Unifacial			
Trianguloid, end scraper	11		17.74
Rectanguloid, side scraper	7		11.29
Flakes	7		11.29
Ovoid	4		6.28
Side-notched	1		1.61
Stemmed	1		1.61

Table 1.—Continued

Artifact	Number Present	Percentage of Total	Percentage of Type
Drills	15	6.25	
Straight shaft	7		46.66
Notched base	5		33.33
Expanded base	3		20.00
Knives	8	3.33	
Blanks	8	3.33	
Graver	1	.41	
Axes	3	1.25	
Celt	1	.41	
Whetstones	3	1.25	
Sandstone tablets	3	1.25	
Pestles	6	2.50	
Mortar	1	.41	
Cupstones	3	1.25	
Hammerstones	3	1.25	
Cannel coal	3	1.25	
Sandstone pendant	1	.41	
Atlatl weights	2	.83	
Sandstone ball	1	.41	
Limestone object	1	.41	
Triangular sandstone object	1	.41	
Unidentified objects	2	.83	
Fragments of ground stone	16	6.67	
Bone	5	2.08	
Shell	7	2.92	
Metal	1	.41	
Total	240	99.93	

Projectile points: The Kirtley site contained eighty-three chipped stone tools tools which can be considered projectile points. These pieces were either whole or broken bases. No tip sections were found during analysis and it seems probable that these were discarded following excavation, as it would be unusual not to have found any tip sections at the site. There were seven major types of projectile points, five of which are illustrated in Figure 5A-E, with slight variations within these types in the form of the base and shoulders. The two predominant types were side-notched projectile points and triangular projectile points. Only three artifacts were too broken to classify.

Scrapers: The sixty-two scrapers can be separated into two basic types—bifacial and unifacial. The bifacial scrapers, illustrated in Figure 5J, were either notched or stemmed and many appear to have been made by utilizing the bases of broken projectile points. The unifacial scrapers, illustrated in Figure 5H-I, are well chipped and shaped into both end and side scrapers.

Drills:There were three types of drills, totaling fifteen artifacts, used by the occupants of the Kirtley site. The most common form was the straight-shaft drill, illustrated in Figure 5F; however, expanded base and notched, expanded base drills were also used.

Knives: The knives varied from irregularly chipped and rough blades to the thin, triangular knife illustrated in Figure 5G.

Graver: One graver has been made from a broken, side-notched projectile point.

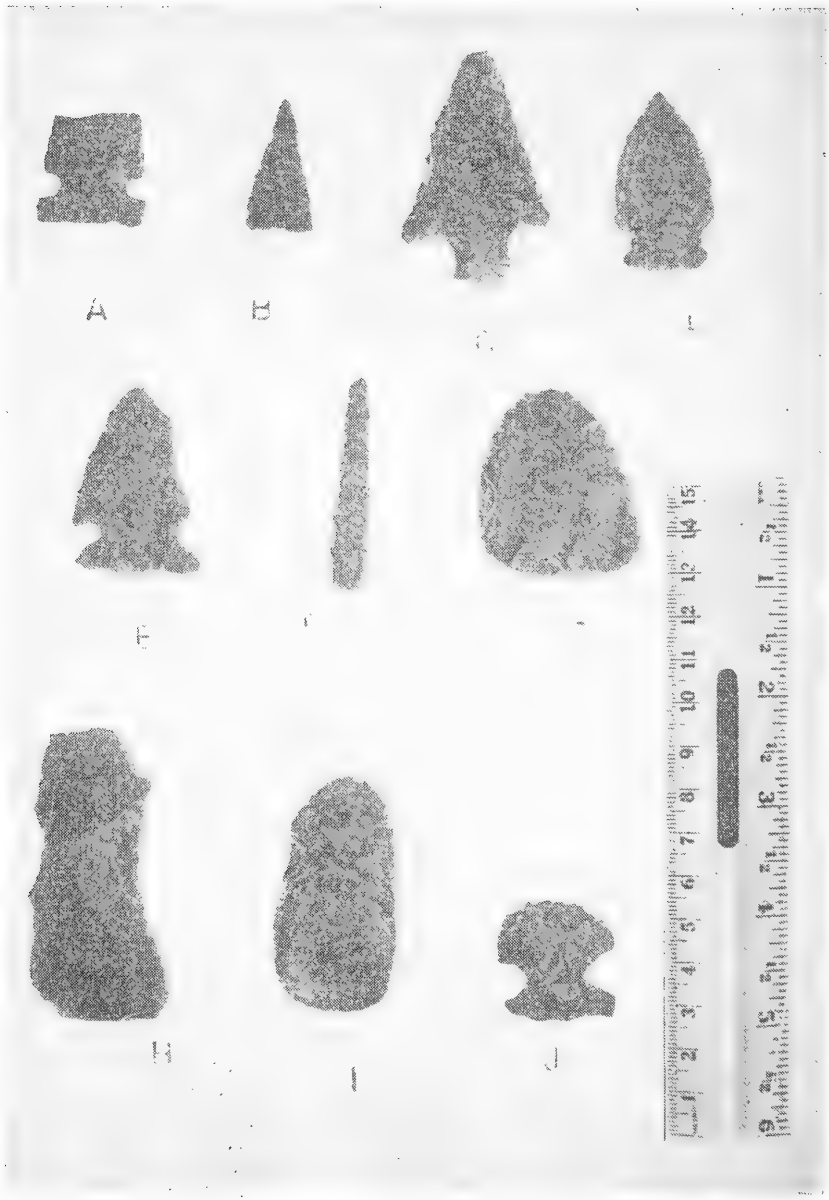

Fig. 5.—Kirtley site chipped stone artifacts. A. side-notched projectile point. B. triangular projectile point. C. stemmed projectile point. D. long, shallow, side-notched projectile point. E. corner notched projectile point. F. drill. G. knife. H-I. unifacial scrapers. J. bifacial scraper.

Axes: All three axes (Figure 6D) were full-grooved with the bit polished to a sharp edge.

Celt: The polished stone celt shows some polish by use on the bit end.

Whetstones: The whetstones were irregular pieces of sandstone with shallow grooves work into the flat surface.

Standstone tablets: These objects were thin fragments of sandstone worked smooth with convex edges and rounded corners.

Pestles: Pestles were of two types, four were cylindrical with one end worked flat, while two were bell-shaped.

Mortar: The mortar was an irregular block of sandstone with depressions on both faces.

Cupstones: Two large, irregular pieces of standstone had been pitted into several small cups on each face. The third was rectangular, and smoothed with both faces lightly pitted.

Hammerstones: Three stone tools were small, roughly cylindrical, with sides and proximal end smooth and one end roughened by hammering.

Cannel coal: Three worked pieces of cannel coal had been smoothed on the edges and faces. They were thin and ovoid in shape.

Sandstone pendant: A thin, nearly circular sandstone pendant with edges smoothed had been drilled at the edge for suspension.

Atlatl weights: Two atlatl weight fragments of polished slate were uncovered. The broken edges had been slightly smoothed. One of these, illustrated in Figure 6E, had been drilled for suspension with a transverse hole.

Limestone object: A small piece of limestone had been worked smooth into an ovoid shape. One end was straight and blunt, while the other sides curved into one continuous edge and had been ground to a sharp edge. Its use is conjectural.

Triangular object of sandstone: A piece of sandstone had been ground to form a thick triangle. Its use is conjectural. This object is from the pit with mixed historic and prehistoric artifacts.

Unidentified objects: Two stone objects had one and squared off, and the other end beveled. One of these was convex. The use of such objects is conjectural.

Bone: Five bone tools were recovered from the Kirtley site. There are two possibilities as to the scarcity of bone objects: 1) they may not have been used to any extent by the occupants of the village, or 2) they may not have been preserved in the soil. The latter seems most likely, considering the condition of the human bone in the burials.

Flakers: Two sections of deer antler showed use as flakers.

Turtle shell pendant: A small section of turtle carapace had been cut into a rectangle and drilled for suspension.

Bone cylinder: A long, narrow, smooth, cylindrical piece of bone had been broken at both ends. Its use is conjectural.

Bone handle: Feature 14 contained, among other things, half of a bone handle, illustrated in Figure 6A, from some modern utensil such as a knife or fork. The edges were cut smooth, the inner surface was flattened and the outer surface convex. One end was slightly wider than the other. Two holes were drilled for attachment and one of these contained the remnants of an iron pin.

Shell: Shell objects were almost as scarce as bone tools. Seven pieces of worked shell were recovered.

Marine shell columella: One piece of marine shell had been cut away leaving the central columella, illustrated in Figure 6B. It was probably intended as an ornament.

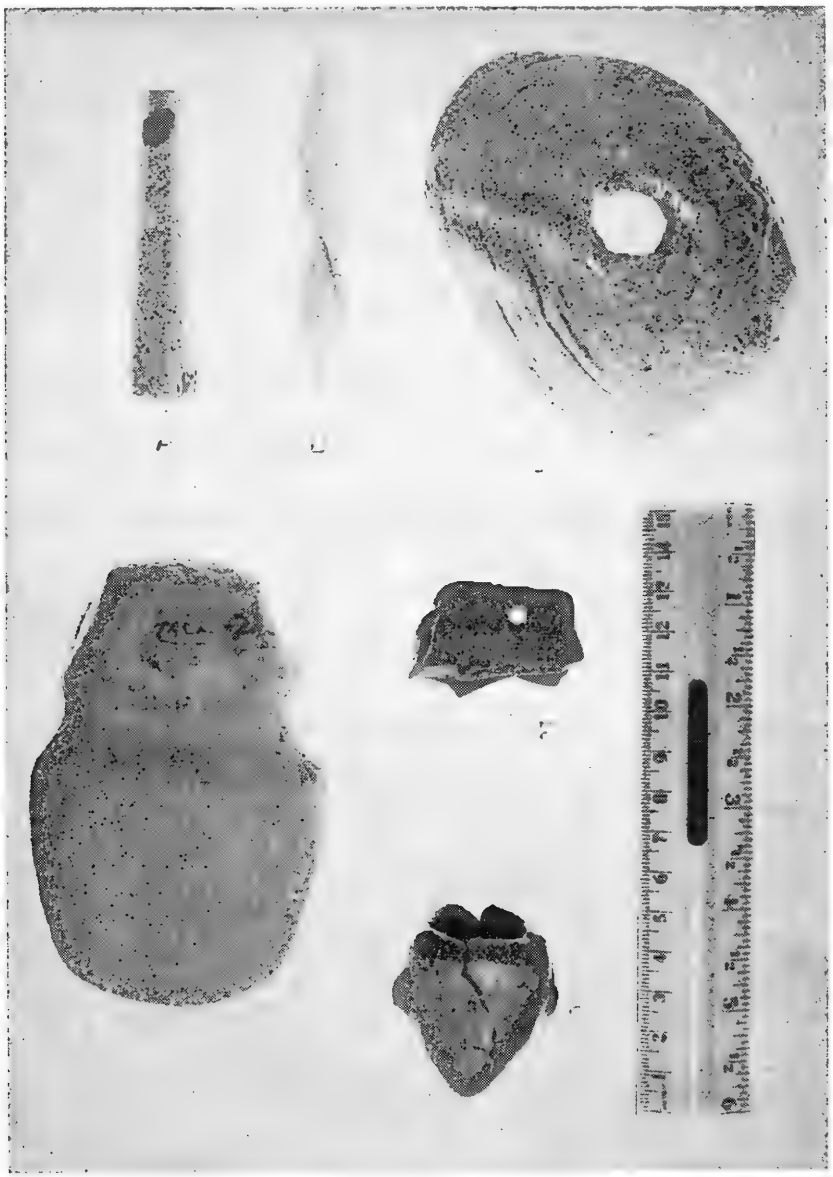

Fig. 6.—Kirtley site artifacts. A. bone handle. B. Marine shell columella. C. Perforated mussel shell. D. full-grooved axe. E. drilled atlatl weight. F. pottery effigy pipe.

Worked fragments: Four fragments of shell indicated varying degrees of use. Three had been drilled, but did not show signs of shaping. One had been smoothed on the edges and sides but not drilled.

Perforated mussell shells: Two large mussel shells (see Figure 6C) had been drilled through the center, but did not appear to be otherwise worked.

Metal: One small, irregular fragment of sheet copper had been perforated in the center. It did not appear to have been made into a bead but may be part of a larger object which had corroded away.

Discussion: Five noteworthy facts stand out from the analysis of the artifacts. First, considering the size of the village, the artifacts are not too numerous. Second, ground stone tools make up less than one fourth of the artifact assemblage and half of these are only partially worked or are too broken to consider as recognizable tools. For a small village of a culture whose economy is based on agriculture, one would expect to find more agricultural tools. The lack of this type of tool may be explained by postulating a use of wooden tools which would have decayed. Fourth, is the lack of artifacts which would be considered ceremonial items, especially for a culture characterized by its ceremonialism. Fifth, is the similarity of artifact types with those present at the Ward site (Webb and Haag, 1940) two miles west of the Kirtley site across Cypress Creek. This site is predominately Archaic with a small Mississippian occupation evident in the upper levels.

Pottery

The pottery at Kirtley, totaling 5507 sherds, is predominately of four types—Neeley's Ferry Plain, Bell Plain, Kimmswick Fabric Impressed and Kimmswick Plain. There was no grit-tempered pottery present although the paste of many of the sherds contained particles of grit and sand which was either part of the tempering material or a characteristic of the clay used in making pottery. Table 2 lists the pottery types present, number of sherds and percentage of the total. As the pottery types conform to published descriptions, only unusual features will be discussed within the pottery types.

Table 2.—Pottery Types from Kirtley Site

Type	Number of Sherds	Percentage
Neeley's Ferry Plain	4723	85.763
Neeley's Ferry slipped or painted	29	.526
Bell Plain	543	9.860
Bell painted	19	.345
Kimmswick Fabric Impressed	98	1.761
Kimmswick Plain	42	.762
Beckwith Incised (?)	1	.018
Shell tempered, net impressed	9	.163
Shell tempered, cord-marked	11	.199
Shell tempered, check-stamped	4	.072
Unclassified	29	.526
Total	5507	99.960

Neeley's Ferry Plain: Three globular jars could be partially reconstructed from Neeley's Ferry Plain potsherds. Five appendages were present: a lug with incised edge which was possibly part of an effigy vessel; a rim sherd with three

large nodes projecting out from the rim; a rim sherd with two small nodes projecting; and two sherds with single nodes. Seventeen handles were present; two loop handles had a single and a double node above the handle on the rim; of the fifteen strap handles, six had two nodes above the handle and three had incising on the rim above the handle. There were two pottery pedestals both of which were flat bottomed and flaring out to the base. A red paint had been applied to the exterior surface of thirteen sherds. In addition, a thin red slip had been applied over all or part of the exterior of sixteen sherds, with slip only occasionally applied to the interior surface.

Bell Plain: Two flat-bottomed bowls could be partially reconstructed with rim diameters of ten and eleven inches. Appendages consisted of a rim sherd with node and one effigy lug which may be the tail piece of an effigy bowl. Five potsherds from one vessel indicated part of an effigy vessel.

Trowel: One fragment of a pottery trowel was convex on the bottom with the upper surface concave.

Pipes: Fragments of three pottery pipes indicated the use of small bi-conoidal pipes. A fourth pottery pipe fragment, illustrated in Figure 6F, is the bowl of a human effigy head pipe. It included such features as the eyes, ears, nose, mouth and tongue.

Discussion: The potsherd types and jar forms conform to the common Mississippian pottery. The only evidences of ceremonialism present at the site are fragments of four possible effigy vessels and an effigy head pipe.

Temporal Placement

There is little evidence at Kirtley on which to base valid conclusions concerning the temporal placement of its occupation. No material was recovered or saved from which a radiocarbon date could be obtained. However, house construction, pottery types and the presence of a midden pit containing historic artifacts, give some indication. Once more is known about the Mississippian culture in Kentucky other factors may be utilized to establish its temporal placement.

The report on Jonathan Creek village (Webb, 1952) in Marshall County is the only recent description of excavations at a Mississippian village site in Kentucky. At this site, the wall trench type houses appeared to precede those constructed with wall posts set individually. In this report, Webb (1952:112-138) hypothesized that the wall trench house was Chickasaw and the individual wall post house was Natchez. The precedence of these two house types could not be determined at Kirtley. If Webb's hypothesis is valid, then the Kirtley site may also have been occupied late in the Mississippian period and into historic times, that is after 1500. The Green River is, however, outside that area usually considered to have been Chickasaw territory.

All of the pottery at Kirtley was shell tempered; however, a tentative temporal placement within the general Mississippian culture can be hypothesized from the type of handles attached to these vessels. Of seventeen handles, two were loop handles and fifteen were strap handles. According to Phillips, Ford and Griffin (1951: 151-153), the

greatest frequency of strap handles in the lower Mississippi River valley occurs in the St. Francis sub-area with the Memphis sub-area following. Toward the south they are rare. These authors theorize that the handle is a northern feature, with a tentative chronological sequence of loop-strap-decorative handles. At the Kincaid site in southern Illinois, the loop handle is present in the early shell tempered levels, and then progressively shifts to the strap type. In the Fort Ancient area loop handles are interpreted as a part of early Mississippian influences. Strap handles are also found in late cultural units continuing into historic times, such as in the Fort Ancient and Oneota Aspects. Therefore, the presence of a high percentage of strap handles at the Kirtley village would indicate a late Mississippian time relationship.

The final piece of evidence for dating lies in the presence of historic artifacts in Feature 14. This midden pit contained refuse of historic origin such as broken dishes, glass fragments, sheet tin, half of a bone handle from a knife or fork, and artifacts of Indian origin such as pottery, a sandstone ball and lumps of clay and sandstone. Unfortunately, the only historic artifact saved was the bone handle. This pit lay some sixty feet north of Feature 2. If it represents contact between Indian and explorer or settler, the village postdates 1550. It is probable that this pit was made after the Indian village had been abandoned. Midden pits with a mixture of Indian and historic artifacts are present on at least two other Kentucky Mississippian sites, Ly 18 and Bt 1 and Schwartz (1961:78) postulated that the pit at Ly 18 was used following the abandonment of the area by the Indians.

Relation to Other Excavated Mississippian Sites in Kentucky

A total of thirty-one excavated sites in Kentucky have artifacts indicating the presence of Mississippian peoples. These sites are located in Figure 2. Fifteen of these appear to be single component sites. These include: Butler 21; Christian 2; Crittenden 1; Hickman 1; Logan 1; Lyon 18; McLean 19; Marshall 4, 11, and 14; Russell 10, 17, and 27; and Trigg 4 and 12. Reports on seven of these sites have been published.

Christian 2, the Williams site (Webb and Funkhouser, 1929) consisted of a mound with a structure on top and a cemetery containing seventeen graves.

Crittenden 1, the Tolu site (Webb and Funkhouser, 1931) consisted of three mounds, one of which was ceremonial and one of which was a burial mound.

Hickman 7, the McLeod Bluff site (Webb and Funkhouser, 1933) consisted of a temple mound, cemetery and village. Parts of the village were excavated.

Logan 1, the Page site, (Webb and Funkhouser, 1930) contained sixty-seven crematory or burial mounds and the remnant of an earthworks.

Lyon 18, the Tinsley Hill site (Schwartz, 1961) was a stone grave cemetery with related village and temple mound.

Marshall 4, the Jonathan Creek site (Webb, 1952) was a rather extensive village with stockades and temple mounds.

Trigg 4, the Duncan site (Funkhouser and Webb, 1931) consisted of a cemetery of sixty-two graves.

There is little evidence on which to base a comparison between these seven sites and the Kirtley village. The house patterns are similar to those at Jonathan Creek. Burial 2 at Kirtley is similar to the burials at Williams, Duncan and Tinsley Hill. The chipped stone artifacts show similarities to those illustrated for Tolu.

The best comparisons can be made with the Jonathan Creek village, M1 4 (Webb, 1952), located on the bank of Jonathan Creek, one mile above its junction with the Tennessee River in Marshall County. But the comparison of traits in Table 3 indicate that the Kirtley people did not have quite the variety or development of Mississippian culture as that present at Jonathan Creek.

Table 3.—Comparison of Traits at Kirtley and Jonathan Creek

Trait	Kirtley	Jonathan Creek
Location of site	on bluff above Cypress Creek bottomlands	on precipitous bank above Jonathan Creek
Stockades with bastions	not enough excavation?	X
House types		
Posts set in wall trenches	13 houses	38 houses
Driven wall posts	2	15
Circular		4
Midden pits	6	70
Storage pits		2
Fireplaces		11
Fire basins		11
Clay basins with raised clay rims		2
Layer of chert fragments		1
Layer of limestone and/or sandstone	2	
Very few burials, no cemetery	X	X
Shallow burials in stone boxes	X	X
Absence of stone box	X	

Table 3.— Continued

Trait	Kirtley	Jonathan Creek
Extended	X	X
Bundle		X
Projectile points		
Side-notched	X	X
Triangular	X	X
Long, shallow side-notched	X	X
Lanceolate	X	X
Serrated	X	X
Stemmed	X	X
Scrapers		
From projectile points	X	X
Unifacial, plano-convex	X	X
Drills		
Straight	X	X
Expanded base	X	X
Graver		X
Reamer		X
Chipped stone celts		X
Whetstones	X	X
Flint hoes		X
Flint picks		X
Abrading stones	X	X
Celts	X	X
Full grooved axes	X	
Discoidals		X
Anvil stones	X	X
Hammerstones	X	X
Stone beads		X
Pestles	X	
Cannel coal	X	
Sandstone tablets	X	
Cupstones	X	
Atlatl weight fragments	X	
Pottery		
Slipped or painted	X	
Loop handles	X	X
Strap handles	X	X
Decorated handles		X
Trowels	X	X
Pottery disks		X
Effigy water bottles	X	X
Effigy lugs		X
Pedestal for jar	X	X
Effigy doll		X
Elbow pipes	X	X
Effigy pipe	X	

Sixteen other excavated sites in Kentucky contain artifacts representative of both Mississippian and earlier cultural manifestations. These sites and the cultural occupations present are listed in Table 4. The location of these sites is indicated in Figure 2.

Table 4. Multiple Component Mississippian Sites in Kentucky

Site	Paleo-Indian	Archaic	Early Woodland	Middle Woodland	Late Woodland	Mississippian
Butler 1 house patterns					X	X
Butler 2-20 house patterns					X	X
Butler 5	X	X	X		X	X
Grayson 12			X	X	X	X
Hopkins 49 house patterns	X	X	X		X	X
McLean 4	X	X	X		X	X
McLean 5		X			X	X
McLean 6 one house			X			X
McLean 7	X	X				X
McLean 11 one house		X			X	X
Marshall 8 house patterns		X				X
Ohio 1		X				X
Ohio 2	X	X			X(Late?)	X
Ohio 19		X	X			X
Trigg 10 one house	X		X			X

This listing points out several significant facts. (1) That some areas were more suited to a variety of economic needs is evident by the use of a site by more than one culture. (2) That some sites were more intensively used by Mississippian peoples is indicated by the presence of house patterns. The use of other sites, indicated mainly by the presence of Mississippian pottery, was apparently rather temporary or superficial. (3) Late Woodland and Mississippian appears to be fundamentally related in the Green River drainage and may represent the continuation of a basic cultural pattern with the gradual addition of some Mississippian traits. (4) Clusters of Mississippian occupations occur on the lower Tennessee and Cumberland, the central Green and the upper Cumberland Rivers. However, this clustering may represent insufficient or selected survey and excavation. The sites on the Mississippi, lower Tennessee and lower Cumberland Rivers are close to the center of Mississippian development. Those on the upper Cumberland River can be accounted for by a spread of Mississippian culture up that river through Tennessee. The more isolated sites on the Ohio River can be accounted for by the spread of Mississippian culture up that river. The sites on the Green River may be due either to spread upstream along the Ohio and Green Rivers or to diffusion overland.

Conclusions

The Kirtley site was a small Mississippian village, probably a farming community. It may have been occupied rather late in Mississippian times. The most outstanding Mississippian features were the house patterns and shell tempered pottery. It did not contain some of the more usual Mississippian traits, especially any indication of ceremonialism, except for fragments of four effigy vessels and one effigy pipe. It was located in what appears at present to have been a rather isolated cluster of Mississippian villages on the Green River.

It would seem that more problems have been raised than have been answered in the description of this village, yet it is hoped that the analysis of the material here will help to develop a picture of Mississippian culture in Kentucky which will in turn solve some of the problems left unanswered at this site.

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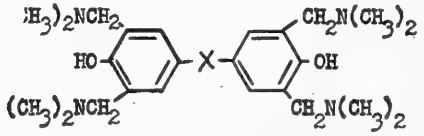
PREPARATION OF SEVERAL SYMMETRICAL BISPHENOLIC MANNICH DERIVATIVES OF BIOLOGICAL INTEREST

C. J. KORPICS, W. T. SMITH, JR., and J. R. MEADOW
Chemistry Department, University of Kentucky

Considerable interest in the application of chemotherapy and the inhibition of cancer has been evident during the past two decades. One approach has centered about the study of antimetabolites. For example, Geschickter, Copeland and Scholler (1951) were interested in finding amino acid antagonists which would be expected ultimately to affect nucleic acid synthesis. Accordingly, they synthesized and studied a number of symmetrical bisphenolic compounds containing amino groups (I, II).

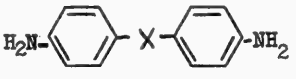


I, II

I 4,4'-Dihydroxy-3,3',5,5'-tetrakis(dimethylaminomethyl)diphenylketone, where X = >C=O

II 4,4'-Dihydroxy-3,3',5,5'-tetrakis(dimethylaminomethyl)diphenyl ether, where X = -O-.

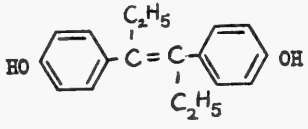
Their investigation no doubt was prompted by the work of Boyland (1946) who reported the carcinolytic properties of 4,4'-diaminodiphenylether (III) and 4,4'-diaminodiphenylsulfoxide (IV).



III, IV

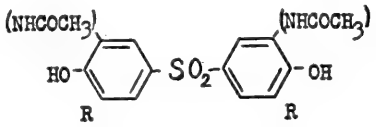
III Where X = -O-. IV Where X = -S- (O)

Interest in symmetrical phenolic type compounds was further substantiated by the well known carcinolytic agent, diethylstilbestrol (V).



V

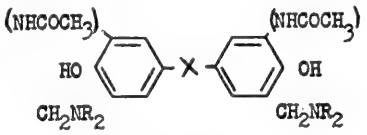
Meadow and Reid (1954) continued the work of Geschickter and co-workers in attempting to prepare new antimetabolites for further study. Among those which showed some promise in this direction were two amino derivatives of 4,4′-sulfonyl-*bis*-(2-acetamidophenol) (VI, VII).



VI, VII

VI Where R = $-CH_2N(C_2H_5)_2$ VII Where R = $-CH_2N(CH_3)_2$

The latter compound (VII) was reported by O'Brien and Meadow (1958). Encouraging results from physiological tests on VI and VII have prompted further study along these lines. The present investigation reports the preparation of some analogous compounds from *bis*-acetamidophenols wherein the central atom or group has been varied and is either an oxygen atom (VIII), a carbonyl group (IX), or an isopropylidene group (X).



VIII, IX, X

R_2 = dimethyl or morpholine group

IX Where X = $-C=O$

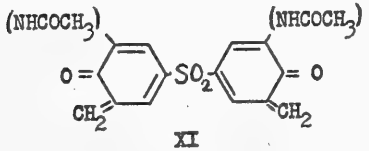
VIII Where X = $-O-$,

X Where X = $CH_3-\overset{CH_3}{\underset{|}{C}}-CH_3$

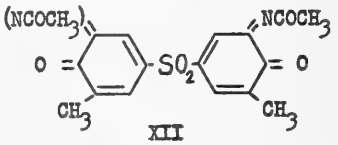
Six new Mannich derivatives from *bis*-acetamidophenols have been prepared (Table III) and they will undergo further study later as to their specific physiological properties. The overall synthesis of each compound involved careful nitration of the corresponding *bis*-phenol, reduction of both nitro groups to amino groups, acetylation of the diamino compound, and finally the introduction of a Mannich group (dimethylaminomethyl and/or morpholinomethyl) in the position *ortho* to the hydroxy group in each ring. The nitro compounds, the amines, and the resulting *bis*-acetamidophenols used as intermediates are listed in Table II. The di-Mannich derivatives of all the *bis*-acetamidophenols having open *ortho* positions were prepared with the exception of the dimorpholinomethyl derivative of 4,4′-isopropylidene-*bis*-(2-acetamidophenol). In this case only the monomorpholinomethyl derivative was obtained.

During the isolation procedures of all Mannich products from *bis*-acetamidophenols it was observed that these compounds appeared to be rather unstable in heated solvents and highly colored solutions usually resulted. This fact was further verified when any of the derivatives were placed on a melting point block and heated to temperatures above 150°. All of the compounds slowly turned to a brick red color.

These highly colored products suggest the formation of a quinoid structure somewhere in the compound, especially when one of the decomposition products is known to be a volatile amine. Preliminary studies on the heat degradation of Mannich compounds from *bis*-acetamidophenols, using 3,3′-diacetamido-4,4′-dihydroxy-5,5′-*bis*-(dimethylaminomethyl)-diphenylsulfone (VII), have shown that dimethylamine is evolved when the compound is heated to 200° or above in a stream of nitrogen gas. The red or orange-red residue is believed to have a mono- or a diquinoid structure depending on conditions of heating. Analysis points to the diquinoid compound (XI or XII) after exhaustive deamination has taken place.



XI



XII

The ease with which these Mannich derivatives form quinones suggests a possible mode of biological action. Lehmann (1947) found diethylstilbestrol, which readily forms a quinone, to be capable of inhibiting the mitosis of *Tubifex* eggs in exceedingly low concentrations. Benzoquinone, napthoquinone and phenanthraquinone were even more active than diethylstilbestrol. A number of other quinones were shown to possess antimitotic action by Reed (1949), and compounds capable of forming quinones such as diamino, dihydroxy and hydroxy-amino compounds were shown to be active by Parmentier (1948, 1949). Phenols and amines not easily oxidized to quinones were shown not to be active in this respect.

Experimental

3,3′-Dinitro-4,4′-dihydroxydiphenyl ether. To a stirred solution of 10.1 g. (0.05 mole) of 4,4′-dihydroxydiphenyl ether in 160 ml. of glacial acetic acid and 100 ml. of benzene was added 9.08 g. (0.10 mole) of concentrated nitric acid over a 2-hour period while the temperature was kept at 0.5°. The reaction was continued for 1-hour and then the

mixture was poured into 2 l. of cracked ice, filtered, and washed with cold water to give 10.9 g. (75%) of crude product, m.p. 145--155°. Five recrystallizations from 95% ethanol gave an analytical sample which softened at 153° and melted at 159--161°. Analysis indicated that the sample was solvated.

Anal. Calcd. for $C_{12}N_2O_7H_8.C_2H_5OH$: N, 8.28. Found: N, 8.49.

3,3'-Dinitro-4,4'-dihydroxybenzophenone. To a stirred solution of 21.4 g. (0.10 mole) of 4,4'-dihydroxybenzophenone in 300 ml. of glacial acetic acid was added a solution of 13.9 ml. (0.22 mole) of concentrated nitric acid in 300 ml. of glacial acetic acid over a 2.5 hour period while the temperature was kept at 20-25°. The mixture was stirred for an additional hour, cooled, filtered and washed with cold water to give 20.2 g. (66%) of product, m.p. 192-7°. Four recrystallizations from glacial acetic acid raised the m.p. to 199-200°.

Anal. Calcd. for $C_{13}N_2O_7H_8$: N, 9.21. Found: N, 9.50.

Since Consonno (1904) reported a m.p. of 172° for this compound, we have further established the nature of our product by converting it to *3,3'-dinitro-4,4'-diethoxybenzophenone,* m.p. 155-156°.

Anal. Calcd. for $C_{17}H_{16}N_2O_7$: N, 7.78. Found: N, 7.75.

Bis-aminophenols. The following procedure illustrates the general method used for the preparation of the aminophenols listed in Table I.

To a suspension of 13.6 g. (0.04 mole) of 3,3'-dinitro-4,4'-dihydroxydiphenylsulfone in 130 ml. of 95% ethanol and 75 ml. of water was added 6.8 g. (0.21 mole) of 95% hydrazine and 1 g. of Raney nickel catalyst. The deep red solution was refluxed gently for 0.5 hour after which time an additional 6.8 g. of hydrazine was added and refluxing was continued for another 0.5 hour. Completion of the reaction was indicated by a color change from deep red to pale yellow. In some cases it was necessary to add an additional portion of hydrazine to complete the reduction. The hot solution was filtered to remove nickel and the filtrate was evaporated to dryness under reduced pressure to give 10.9 g. of brown solid. Recrystallization from 1.5 l. of water gave 7.9 g. (71%) of 3,3'-diamino-4,4'-dihydroxydiphenylsulfone, m.p. 233-235° (decomp.).

Anal. Calcd. for $C_{12}H_{12}N_2SO_4$: N, 9.96. Found: N, 10.00.

Bis-acetamidophenols. The following procedure illustrates the general method used for the preparation of the compounds listed in Table II.

To a suspension of 7.74 g. (0.03 mole) of 4,4'-isopropylidene-*bis*-(2-aminophenol) in 150 ml. of glacial acetic acid was added 6.4 g.

Table I.—Melting Points, Yields and Analyses for the Diaminophenols

Compound	Melting Point ° C.	Recrystallizing Solvent	Yield %	Formula	Nitrogen % Calcd.	Nitrogen % Found
3,3′-Diamino-4,4′-dihydroxydiphenylsulfone	233-235	Water	71	$C_{12}H_{12}O_4SN_2$	9.96	10.00
4,4′-Isopropylidene-bis-(2-aminophenol)	243-246 dec.	95% Ethanol	85	$C_{15}H_{18}O_2N_2$	10.85	10.71
4,4′-Isopropylidene-*bis*-(2-amino-6-methylyphenol)	140-140.5	Methanol-Benzene	99	$C_{17}H_{22}O_2N_2$	9.78	9.59
4,4′-Isopropylidene-*bis*-(2-amino-6-isopropylphenol)	187-190 dec.	Ethyl Acetate	84	$C_{21}H_{30}O_2N_2$	8.18	8.09
3,3′-Diamino-4,4′-dihydroxydiphenylether	185-188[a] dec.	.....	92	$C_{12}H_{12}O_3N_2$	12.06	11.94
3,3′-Diamino-4,4′-dihydroxybenzophenone	235-237 dec.	Methanol	88	$C_{13}H_{12}O_3N_2$	11.47	11.42

[a] Recrystallization was ineffective because of the instability of the compound.

Table II.—Melting Points, Yields and Analyses for the Diacetamidophenols

Compound	Melting Point ° C.	Recrystallizing Solvent	Yield %	Formula	Nitrogen % Calcd.	Nitrogen % Found
4,4′-Isopropylidene-*bis*-(2-acetamidophenol)	262.5-263.5	Absolute Ethanol	92	$C_{19}H_{22}O_4N_2$	8.18	7.92
4,4′-Isopropylidene-*bis*-(2-acetamido-6-methylphenol)	74-78	Reprecipitation[a]	53	$C_{21}H_{26}O_4N_2$	7.56	7.63
4,4′-Isopropylidene-*bis*-(2-acetamido-6-isopropylphenol)	76-78	Reprecipitation[a]	94	$C_{25}H_{34}O_4N_2$	6.57	6.45
3,3′-Diacetamido-4,4′-dihydroxydiphenylether	208-210	Methanol	85	$C_{16}H_{16}O_5N_2$	8.86	8.61
3,3′-Diacetamido-4,4′-dihydroxybenzophenone	290-291	Dimethylformamide-water	94	$C_{17}H_{16}O_5N_2$	8.53	8.51

[a] Purified by reprecipitation of the potassium salts.

Table III.—Melting Points, Yields and Analyses for the Mannich Derivatives of the Diacetamidophenols

Compound	Melting Point ° C.	Recrystallizing Solvent	Yield	Formula	Nitrogen % Calcd.	Nitrogen % Found
4,4′-Isopropylidene-*bis*-(2-acetamido-6-N,N-dimethylaminomethylphenol)	136-137.5[a]	Acetone	60	$C_{25}H_{36}O_4N_4$	12.27	11.97
4,4′-Isopropylidene-6-morpholinomethyl-*bis*-(2-acetamidophenol)	118.5-120.5[b]	Benzene	98	$C_{24}H_{31}O_5N_3$	9.53	9.42
3,3′-Diacetamido-4,4′-dihydroxy-5,5′-*bis*-(N,-N-dimethylaminomethyl)-diphenylether	169-171[c]	Acetone	51	$C_{22}H_{30}O_5N_4$	13.02	12.71
3,3′-Diacetamido-4,4′-dihydroxy-5,5′-*bis*-(morpholinomethyl)-diphenylether	191-192.5[d]	Benzene	93	$C_{26}H_{34}O_7N_4$	10.89	10.71
3,3′-Diacetamido-4,4′-dihydroxy-5,5′-*bis*-(N,N-dimethylaminomethyl)-benzophenone	208-220[e]	Acetone	57	$C_{23}H_{30}O_5N_4$	12.66	12.20
3,3′-Diacetamido-4,4′-dihydroxy-5,5′-*bis*-(morpholinomethyl)-benzophenone	268-269[f]	Dimethyl-formamide	80	$C_{27}H_{34}O_7N_4$	10.64	10.43

[a] Melted to a yellow gum and had a neutralization equivalent of 460.4. The calculated value was 456.5.
[b] Melted to a clear gum.
[c] Melted to a brown viscous liquid. The neutralization equivalent was 433.8; the calculated value was 430.5.
[d] Melted to a red viscous liquid. The neutralization equivalent was 528.6. The calculated value was 514.5.
[e] Paced on the melting point block at 215° and melted to a bright red gum. The neutralization equivalent was 457.7. The calculated value was 442.5.
[f] Placed on the melting point block at 250° and melted to a bright red gum. The neutralization equivalent was 508.5. The calculated value was 526.3.

(0.06 mole) of acetic anhydride and the mixture was heated on a steam bath for 5 hours. The mixture was cooled and filtered and the precipitate was washed with dilute hydrochloric acid and water to give 9.4 g. (92%) of 4,4′-isopropylidene-*bis*-2-acetamidophenol, m.p. 262-263.5°.

Mannich derivatives of the bis-acetamidophenols. The following procedure is typical of that used to prepare the compounds listed in Table III.

To a suspension of 3.4 g. (0.01 mole) of 4,4′-isopropylidene-*bis*-(2-acetamidophenol) in 6.2 g. (0.035 mole) of an aqueous 25% dimethylamine solution and 5 ml. of ethanol was added 2 g. of 37% aqueous formaldehyde over a 45 minute period with swirling and cooling. The mixture was allowed to stand at room temperature 4 hours, was heated on a steam bath for 4 hours, and was then diluted with 200 ml. of acetone. The acetone was removed on a steam bath, more acetone was added and this process was repeated until the strong odor of amine was removed. Finally, the acetone solution was allowed to stand at room temperature while the walls of the flask were scratched frequently with a glass rod. The orange powder which eventually separated weighed 2.75 g. (60%), m.p. 124-131°. Two recrystallizations from acetone gave an analytical sample, m.p. 136-137.5°.

Summary

A number of Mannich derivatives of some *bis*-phenols have been prepared for testing of their carcinolytic activity. These *bis*-phenols have different central groups, such as an isopropylidene group, a carbonyl group, or an oxygen.

ACKNOWLEDGEMENT

The authors wish to thank the Geschickter Fund for Medical Research, Washington, D. C., for help and cooperation in carrying out the present research program. Especially do they appreciate the helpful suggestions of Dr. C. F. Geschickter of the Georgetown Medical School, and also Dr. E. Emmet Reid, Professor Emeritus of Johns Hopkins University.

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A CANNEL COAL TENSION RUPTURE

ALLEN L. LAKE
Morehead State College, Morehead, Kentucky

On September 12, 1960, an anticline-like fold began forming in a stratum of cannel coal in the Breathitt formation on the Rush Branch area of Morgan County, Kentucky (Lennox quadrangle). The one meter thick seam of coal had been prepared for strip mining by the removal of an overburden of sandy shale ranging in thickness from two to six meters. The actual fold ran longitudinally for a distance of twelve meters, and had a width of four meters at the widest point. The fold extended from the working face of the mine with a gradually tapering shape to the plunging end of its anticlinal aspect.

Cannel Coal in Eastern Kentucky typically appears showing three somewhat different grades of coal in each stratum. These are called, in order from the upper surface downward, top curly, table block, and bottom curly. The upper and lower parts of the sandwich display a characteristic conchoidal fracture when broken, hence the term, curly. The middle portion of the stratum retains a rectangular appearance reminiscent of the cuboidal nature of the standard grades of bituminous coal from which it derives its description, table block.

In the fold, the table block proved less yielding to tension pressures and either fractured openly or retained its original shape. The top curly underwent considerable bending for a material that is so brittle.

Mining operations were going on when the deformation began. Loud snapping noises were reported, and the rising stratum could be perceived. Workers on the section ran from the area. Local miners, many of whom have had considerable experience with cannel coal, indicated that they had never seen anything like this before. The miners postulated that the heat from the sun had caused an expansion of the exposed surface and caused the rupture. However, such strata are often exposed to direct sunlight without similar results.

The major difference between this area and other strip mines was its location in respect to the natural drainage pattern. The cannel coal stratum had held a position directly under a small intermittent creek bed. In preparing the area for mining, bulldozers had pushed rock and soil upstream forming a dam across the natural drainage trough. Since the season was relatively dry, no enpondment was maintained. Nevertheless, there was evidence that water had collected at some time and had either evaporated or percolated downward through the soil and rock. Below at the site of the rupture, a steady trickle

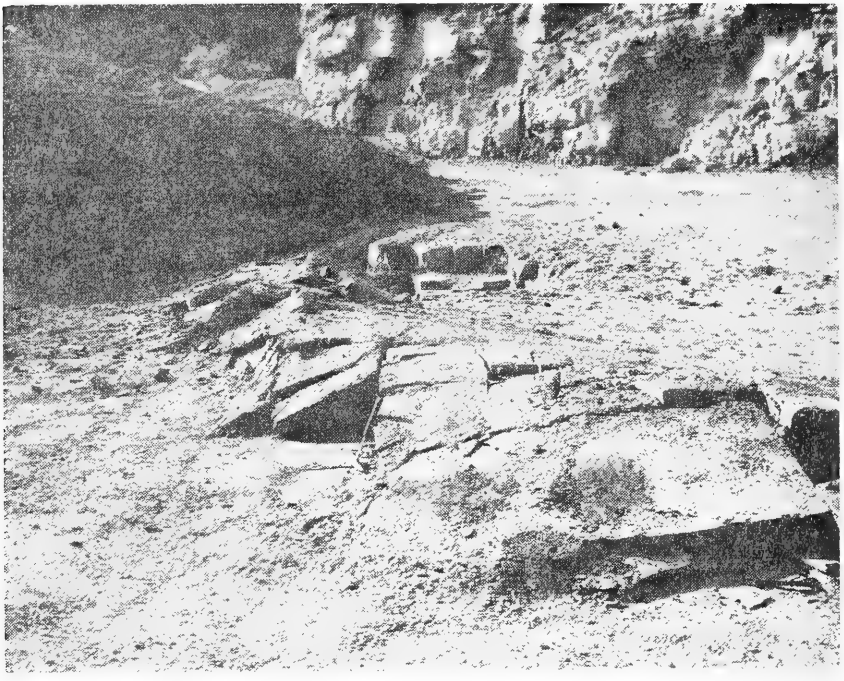

Fig. 1.—A cannel coal tension rupture.

of water was emerging from under the cannel coal stratum. The non-affected portion of the stratum was dry.

It is possible that heat may have been a contributing factor to the total tension within the stratum, but a determining factor seems to have been the presence of a continuous supply of water at the actual site of the bulge. Absorption of water by cannel coal may be the distinguishing feature of such an occurrence.

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QUINALDINE AS AN ANESTHETIC ON *SIREDON MEXICANUM* (SHAW)

ROGER M. KATZ

Contribution No. 45 (New Series) from the Biology Department,
University of Louisville, Louisville 8, Kentucky

Experimenters dealing with aquatic heterothermous animals are confronted with the problems of how to keep the animals non-sensitive and inactive during surgical and postsurgical stages. Insensitivity is desirable not only for humane reasons but also to facilitate handling of normally slippery animals and to reduce the chances of accidental injury.

Chemical anesthesia is more acceptable than physical anesthesia through chilling or electrical shock because the latter may cause severe stress leading to physiological shock syndromes (Pickford and Atz, 1957). Among the chemical anesthetics, qinaldine (2-methylquinoline) provides the inactive and insensitive state that decreases the chances of physiological shock and mishaps (Muench, 1958). McFarland (1960) presented a good review of anesthetics used in fisheries, their effective concentrations, and their advantages and disadvantages. He does not discuss the uses of quinaldine, but he states that through anesthesia the loss of motility and muscle tone along with the loss of equilibrium and reflex activity are desirable for operating and handling. Quinaldine has also been used as an anesthetic on the guppy for radiation experiments (Balling and Scott, in press). This report is on the usefulness of quinaldine as an anesthetic on the axolotl, *Siredon mexicanum* Shaw.

According to Newth (1960) this salamander was first noted by Francisco Hernandez about 1520, and was first described in zoological literature as *Gyrinus mexicanus* by Shaw in 1789 (Smith and Taylor, 1948). The common name "axolotl" is the original Aztec designation. All individuals used in this experiment were obtained from stock of Dr. R. R. Humphrey, Department of Zoology, Indiana University. Both albinistic and normally pigmented animals were used; the former stemmed from individuals brought from Poland in the 1930's, and the normally pigmented stock were bred in Germany for some time before being brought to the United States. Albino axolotls apparently descended from crosses made in Paris by Dumeril at the Jardin des Plantes in 1868 of spotted and black axolotls (Newth, 1960). The albinism is inherited as an autosomal recessive and was achieved atfer several backcrossings.

Quinaldine has the formula $CH_3\ C_9\ C_6\ N$, a molecular weight of 143.18, and specific gravity of 1.059 $\frac{20}{4}$ °. It is a colorless, oily liquid

that turns brown on exposure to air. It occurs in coal tar, is slightly soluble in water, has a quinoline odor, and is made from aniline, acetaldehyde, and hydrochloric acid (Stecher, 1960). The quinaldine used in this experiment was manufactured by Matheson, Coleman, and Bell, practical grade, batch number 394126.

The anesthetic was stirred vigorously in four liters of water in a five-liter battery jar until it became finely suspended. The time required for each of 9 concentrations, ranging 32 to 528 mg/l, to produce deleterious effects was measured in order to determine the optimal concentration for prolonged anesthesia.

After the suspensions were prepared, one animal was placed in each battery jar. Removal of the animal from the quinaldine suspension involved rinsing with cold tap water and then placing it in fresh aerated water for recovery. Controls maintained in city tap water showed no harmful effects from purification additives which were presumably present. Experimentation and recovery procedures were carried out at room temperatures. Thirteen different animals were used for a total of 38 experimental runs. The average weight of the animals used was 81.4 grams with only one animal below 80 grams (70.1 grams) and none above 90.6 grams. All animals were fed 36 to 48 hours before experimentation.

Results

There is a direct relationship between the concentration of quinaldine used to induce anesthesia and the time required for total anesthesia (Figure 1). Results were obtained in the range of 80 to 528 mg/l but concentrations greater than 528 mg/l proved lethal in all experiments. No adverse effects were noted in 260 to 400 mg/l range if the animals were promptly transferred to a lower concentration of 96 mg/l after total anesthesia was achieved, whereas those kept in 264 mg/l for an exposure of five hours and then transferred to fresh water suffered a swelling of the mandibular region and an apparent tetanus of the muscles in that region. Animals in this condition had typical reactions to stimuli, but the mandibular muscles were insuch pronounced tetany that even when pressure was applied the mouth could not be opened. If forced fed, the food was regurgitated within a few hours. After about two weeks of "starvation" the animal died. This indicates damage to the branchial region or innervation thereof, and/or to the gastrointestinal tract. Other indications of gastrointestinal disturbance were that 45 percent of the animals placed in varied concentrations of quinaldine for different lengths of time regurgitated, whereas only 30 percent regurgitated when recovery was effected immediately after being induced

with anesthesia; no significant correlation appears between the regurgitation and death. It seemed to be an individual characteristic, with a greater incidence at lower concentrations than at higher concentrations.

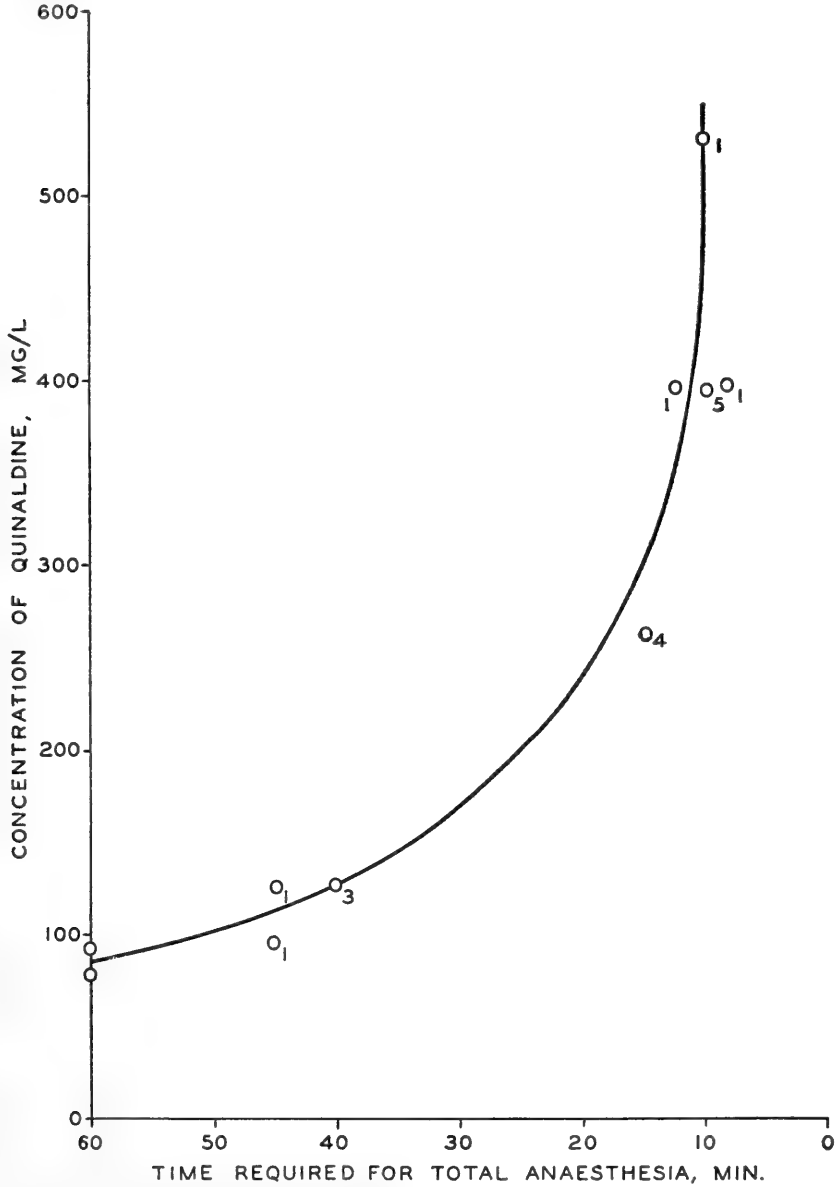

Fig. 1.—Concentration of quinaldine vs time required for total anesthesia (Quinaldine concentration as mg/1 of water)

The high concentrations, 264 to 396 mg/l, were lethal after five hours of exposure. However, the transferring of the ainmals from this range to lower concentration after 4 hours was not attempted. Below 80 mg/l anesthesia was only partial with activity and sensitivity retained, and if the animals were left at this level for 4 or 5 hours, death sometimes occurred.

A concentration of 96 mg/l of quinaldine appeared to give the most desirable, prolonged anesthesia. In some cases the axolotls were

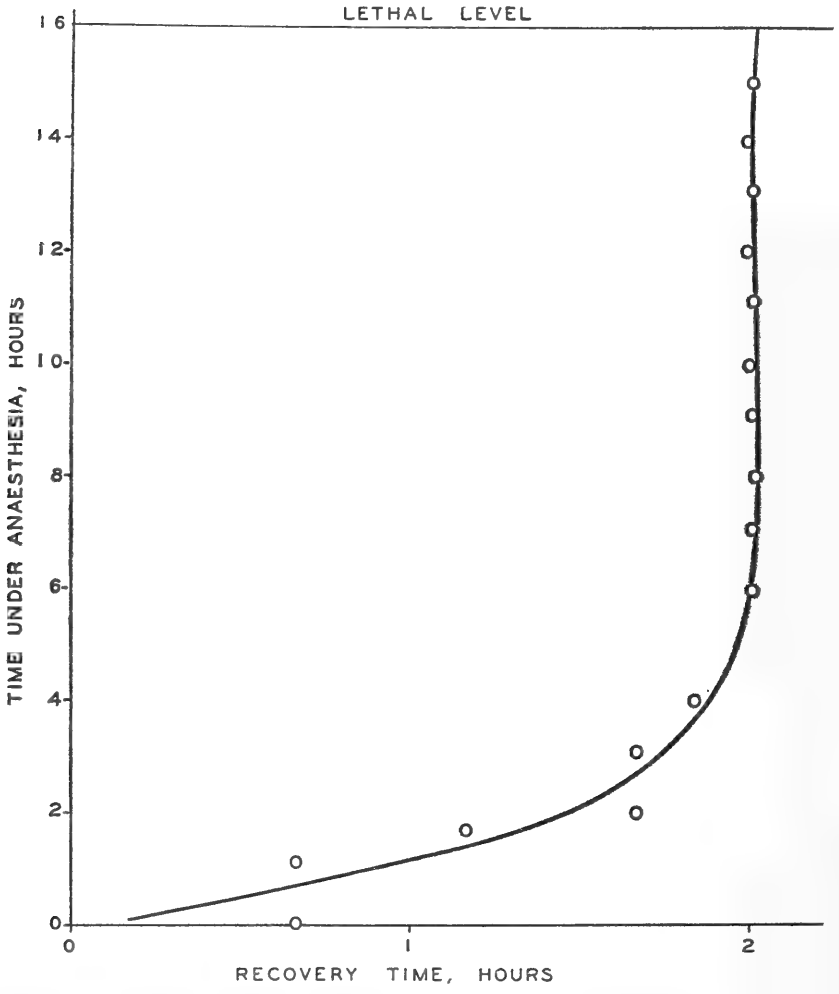

Fig. 2.—Time under anesthesia vs time required for recovery. (Quinaldine concentration 96 mg/1. See text for further explanation.)

initially anesthetized at a higher concentration of 396 mg/l and then transferred to the 96 mg/l concentration immediately after anesthesia was induced. This reduced the experimental time by 40 minutes and there were no apparent differences between those initially placed in higher concentrations and those which were induced in the 96 mg/l concentration. Consequently the 396 and 95 mg/l data are combined in Figure 2. This figure shows an increase in recovery time with increase in exposure time until about two hours. Recovery remains at this "plateau" until exposure was increased to lethal time of 16 hours (Figure 2). Individuals kept 16 hours under anesthesia died a short time after transfer to fresh water. After sustained anesthesia it was observed that recovery usually occurred first on one side of the body and then on the other. This occurred in no particular sequence. One side of the body appeared to be temporarily paralyzed. No permanent effects on the sensory nervous system were noticed.

Recovery time after immediate removal of the animal from various concentrations of quinaldine to fresh water is related to the concentrations of quinaldine used, but there were individual differences (Figure 3). The greatest difference is between 132 and 264 mg/l concentration. The others appear to follow a more or less direct relationship. Some of the axolotls in this experiment were subjected several times to various doses of anesthetic and in no case were adverse effects observed. Reproduction occurred one month after experiments ceased; hence, this capacity was not affected.

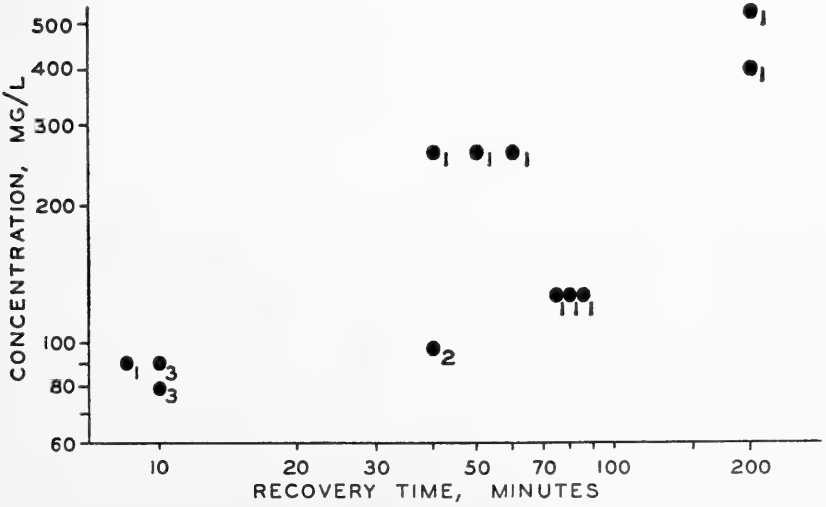

Fig. 3.—Concentration of quinaldine vs time required for recovery. (Animals were removed to fresh aerated water immediately after anesthesia induction).

Discussion and Conclusions

Quinaldine has an effective use at relatively wide range of concentrations, has little adverse effects if used properly, and may be used to maintain anesthesia over a relatively long period of time. In this experiment 96 mg/l at 15 hours was the most desirable concentration and the longest duration under anesthesia. The undesirable effects of quinaldine on the axolotls correspond with those of chloretone on *Ambystoma punctatum* embryos, as reported by Carmichael (1926). Carmichael found that defects due to a stronger than tolerable dose of chloretone resulted in bloating of the whole body which either ended in death or seriously interferred with later movements. The present results resemble also those of McFarland (1960), if higher concentrations of various anesthetics were used for anesthesia in fishes the specimens had to be removed promptly after induction; however, these results of axolotls differ with McFarland's findings that fishes were able to be held under sustained anesthesia (12 hours) without fatality if dosages slightly below the lethal concentration were used. The time of about ten minutes to induce deep anesthesia in axolotls at high concentrations of quinaldine is in agreement with that of other anesthetics used on large fish. McFarland (1960) and Muench (1958) both found that recovery time was proportional to the length of exposure and to the concentrations of the anesthetic. They along with others found that recovery after anesthesia of one or more exposures appears to be complete and without adverse, long term effects. These agree with the present experiment.

If used in proper concentrations, quinaldine is found to possess the following useful anesthetic properties: 1) it is low in cost and can be either synthesized or obtained as a by-product of coal tar; 2) it is slightly soluble in water but if mixed vigorously, a fine suspension will form that is ideal for inducing anesthesia; 3) it can be used over a wide latitude, 80 to 528 mg/l with axolotls; 4) it can induce anesthesia in nine to ten minutes at high concentrations from 396 to 528 mg/l, and in fifty minutes at 96 mg/l; and, 5) anesthesia in axolotls can be maintained up to 15 hours at 96 mg/l, or at higher concentrations anesthesia could be maintained up to four hours with no apparent permanent, adverse effects. After knowing the quinaldine characteristics and its desirable concentrations, it is recommended for use.

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A FOOTNOTE ON HORSE RACE BETTING

RICHARD M. GRIFFITH
Veterans Administration Hospital, Lexington, Kentucky

In an early note Griffith (1949) showed that horse race bettors put too much money on horses which have little chance of winning and too little on those most likely to win. McGlothlin (1956) repeated the study, confirming the results and revealing many further potentialities in the data by considering the position of the race in the day's program. An obvious extension of the analysis—one which McGlothlin picked up but brushed over lightly—is to turn from win betting to "show" betting. The person who would like to bet on a surer thing than even the heavy favorite to win the race may bet that he will "place," that is, finish first *or* second, or, what is more likely yet, that he will "show," finish third or better. The tendency to under-bet the most probable event should appear in its most marked degree in show betting.

The reader who does not have a fundamental conception of the mechanics of pari mutuel betting may refer to one of the above references for sources. The bettor pits his skill against that of the crowd, for the pattern of their bets determines the odds. All bettors suffer under the handicap, however, that taxes and the track "take" 13-15 percent of the pool before it is divided among those with winning tickets and the amount is further reduced through "breakage," the loose change of pennies and nickels with which the track can't be bothered and which it therefore keeps. Opinions vary as to whether anyone can overcome such handicaps and win consistently.

In show betting the amounts of money bet into the show pool on the various horses also determines the amount to be returned to those bettors who win. However, the division is more complicated. Whereas the totalisator keeps the patrons informed at 45 second intervals as to the approximate amount to be returned on a horse to win, the pay-off to show cannot be easily computed because it depends on the other two horses which finish with him. After the race is run, the amount bet on each of the first three horses is removed from the total show pool, the pool first having been reduced, of course, by the take. These amounts will return to the winning bettors their original investments. The profit to the bettors on each horse is determined in a debatable way: by splitting what is left in the pool evenly three ways, irrespective of how likely or unlikely each horse had been to qualify. Furthermore, it may be realized, loss through breakage is proportionately greater at the smaller pay-offs. All of which is to say that the show bettor can

have no clear notion of how much he stands to win.[1] He knows that he will generally collect less for a show bet on the favorite than on a long shot but he can only have a vague idea of how much less. His betting on horses to show, and particularly on the horses with short odds-to-win to show, can reflect only his desire to bet on the surest thing around. The present note, in the nature of a footnote to the previous paper, is aimed at measuring the extent to which bettors do this.

All horses which went to the post at odds-to-win of less than 2 to 1 (returning less than $3 for $1) for two separate months of American racing, May, 1949 and August, 1960, were considered—some 4543 of them.[2] The number which did not show was tabulated as was the pay-off to show for those which did.

As would be expected from the above discussion, the pay-off to show is quite variable; for instance, in the odds-to-win group of 1.80-1.95 to 1, the profit from a dollar bet on horses which did show ranged from .10 to $1.40. In other groups there were instances in which a horse which won the race paid more on a show ticket than he did to win.

There are two ways to compute the *post facto* "odds-to-show": one, depending on how the horses did, is the percent which did not show; the other, depending on what the bettors did, is the average profit (allowing for the horses which did not show). Fig. 1 presents the results. Below odds-to-win of 1.40 to 1, there is systematic underbetting, even to the extent of overcoming the loss to breakage and take, for which these data were not corrected.[3] The lines cross sharply in the 1.40-1.55 to 1 range due to a dip in profits in this range. Since the point of crossing was consistent between the years (and the dip, also, which may or may not mean something), only the combined results need be shown. A rough statistical test of the reliability of the results was a comparison between the two years of the directions of the differences between the two odds-to-show within each class interval: the binomial probability (7 of the 8 being in the same direction) was less than .05.

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[1] From the viewpoint of the bettors as a whole, there is such a thing as a good bet at the race course—one which returns more money to them than they put in; oddly enough, under unusual circumstances the track can lose money. The minimum pay-off permitted by law in most states gives 10 cents profit on the dollar, the winning bettor thus being assured at least $1.10 for his $1. With only a few horses entered in a race and with one of them likely to be established as an overwhelming favorite, the track may suspend show betting to protect itself against a negative pool.

[2] As reported in the *Daily Racing Form Chart Book*, 54, No. 5, 1949 and 45 (sic.), No. 8, 1960, Triangle Publications, Inc., Chicago.

[3] *Cf.* McGlothlin, *op. cit.*, and Griffith, *op. cit.*

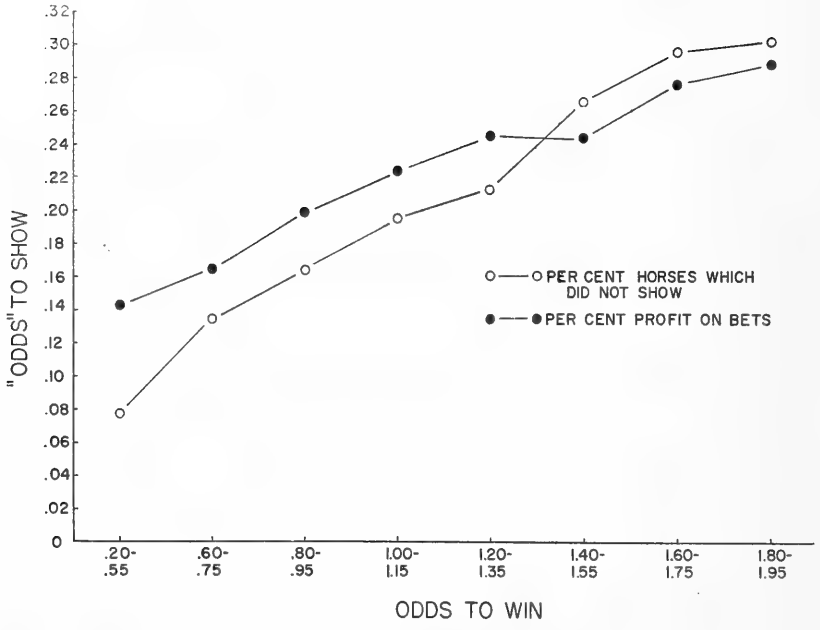

Fig. 1.—*Post facto* "odds" to finish first, second, or third in relation to odds to win.

To interpret the results in other language, a bettor would have shown a net profit had he bet on all horses to show which went to the post at odds-to-win of less than 1.40 to 1 during the periods of this study. Had it been practical to bet on every horse at the proper odds-to-win (546 of them) in May, 1949, he would have netted a profit of 6.15 cents per dollar bet; in August, 1960, his profit would have been 2.4 cents on the dollar (1496 bets).

The difference between the rates of profit in the two years was due to an increase in the number of horses which did not show in 1960. The proportion of losers in the two years differed significantly by the chi square test beyond the .01 level of confidence. The rate of return for those which *did* show rose by 2.6 cents, otherwise there would have been a net loss in 1960. (It would not be prudent with the data at hand to account for these shifts between the two years, accepting them as genuine.) Profits could be improved by other considerations, of course: the careful reader will be able to estimate that McGlothlin (1956, p. 611) found a net profit of around 10 or 11 percent on horses whose odds-to-win were less than 2 to 1 in the eighth race of the day.

Thus, as was to be expected, the tendency, which had been demonstrated with win betting, for horse race bettors to place too little

money on the horses most likely to win is magnified in their even more conservative bets on the same horses to show.[4]

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[4] We have hesitated to report the findings on the 1949 races and their confirmation in 1960. When his results are in real life, the scientist must pause to consider that some may think them practical, use or misuse them. Before one plays the fiddle he should know who will dance. (There was a strange malady epidemic in the Middle Ages (tarantism) which compelled the victim to dance, and he could not stop.) We do not court the distinction of demonstrating a method to "beat the races," even though our home in Kentucky is surrounded by the thorobred industry. As a psychologist we are gratified, however, that the discovery came about from a psychological presupposition—that the spirit of gambling is to risk little to gain much.

A KEY TO PREHISTORIC KENTUCKY POTTERY

DOUGLAS W. SCHWARTZ
Museum of Anthropology, University of Kentucky

INTRODUCTION

Prehistoric Kentucky ceramics have received only slight attention from the archaeologist. This situation has resulted mainly from the fact that the early archaeological work in the state by Funkhouser and Webb was concentrated on non-pottery Archaic and Woodland sites where pottery was not important to the analysis. Recent archaeological work on late prehistoric occupations where pottery was of major importance has necessitated a re-examination of our knowledge of prehistoric ceramics in Kentucky. One result of this work has been the development of a key for the identification of the pottery types used in archaeological analysis. This key is designed for use by professional or amateur archaeologists working in the state or areas immediately adjacent to it, who are attempting to identify the type of pottery found at a particular site or group of sites. The publication of this key is meant to stimulate interest in pottery bearing sites of Kentucky, give the amateur collectors a greater understanding of their own collections, and to make the key available for corrections, checking, and revision. A future publication is planned which will include detailed pottery type descriptions, distribution maps, drawings, more exact time and cultural assignments for each type, as well as a key. Needless to say, the present key is meant only as a beginning and a guide to those interested in the subject who might be able to fill in details from private or public collections.

Following the name of each pottery type, a cultural period has been inserted in parentheses. The approximate temporal and spacial relationship of these four periods can be seen in Figure 1. Although in some cases, fairly definite dates are known for pottery types, in most instances this is not the case. Therefore, no dates have been added to any types. Keys for the identification of pottery types are not common in archaeology. Harold S. Colton began using the technique in northern Arizona in the early 1930's. His interest in keys undoubtedly stems from his background as a zoologist. As far as the author is aware, however, there are no keys for pottery identification in the eastern United States. The development of this outline introduction to Kentucky pottery types, however, has brought to the attention of the author several problems. Foremost is the double naming of pottery types. It will be noted that some can be identified only by knowing the location, either north or south Kentucky. This would imply that a

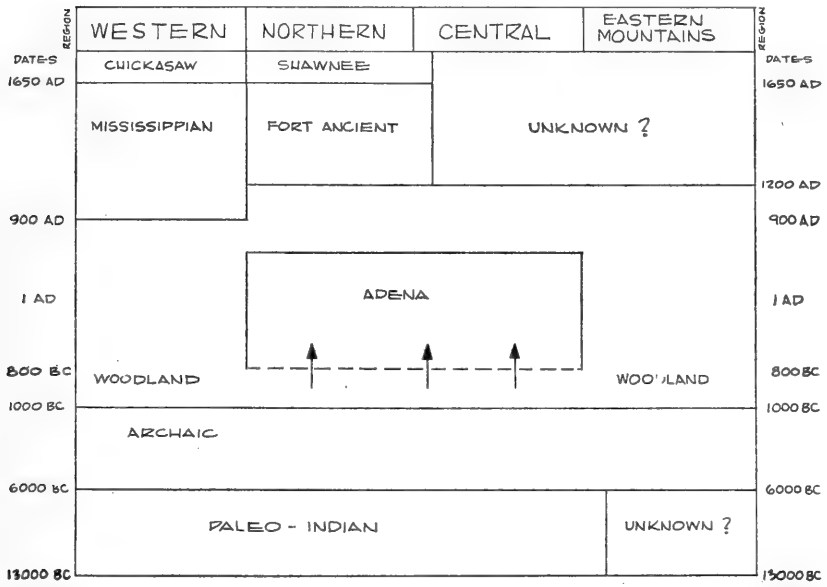

Fig. 1.—Chart presenting the presumed temporal and spatial relationships of archaeological and ethnological cultures in Kentucky.

pottery type originaly named in Ohio and one originally named in Tennessee are in essence the same type. The decision as to whether both of these names should be retained, or only one, it is hoped will be one of the outcomes of the general study of prehistoric pottery now being conducted at the University of Kentucky Museum of Anthropology.

KEY

A. Not shell tempered—C

B. Shell tempered—J

C. Grit tempered
   1. some limestone temper—D
   2. clay temper—E
   3. other grit tempering—F

D. Limestone temper
   1. surface altered—G
   2. surface not altered—H

E. Clay tempered
   1. surface altered
      a. cordmarking
         1. micaceous surface—*Levissa Cordmarked* (Adena)
         2. non-micaceous surface—*Mulberry Creek Cordmarked* (Woodland)
      b. cord wrapped dowel impressed—*Baumer Fabric Impressed* (Woodland)
      c. Individual cord impressed in rectilinear designs—*Baumer Cordmarked* (Woodland)

d. zone incised—*Yankeetown Incised* (Woodland)
e. addition of narrow notched strips of clay below rim—*Yankeetown Fillet* (Woodland)
f. lines at parallel ticks joined by center line—*Yankeetown Pseudo Fillet* (Woodland)

2. surface unaltered—*Baytown Plain* (Woodland)

F. Grit tempered other than limestone and clay
1. flint tempered—*Fayette Thick* (Adena)
2. quartz sand
a. plain surface—*O'Neal Plain*—(Woodland)
b. simple stamped and neck punctations—*Paintsville Simple stamped* (Adena)
c. punctations in cordmarked surface—*Zorn Punctate* (Adena)
3. sand
a. micaceous surface—*Johnson Plain* (Adena)
b. non-micaceous surface—*Rudder Cordmarked* (Woodland)

G. Surface altered limestone temper
1. cordmarked—I
2. incised—*Montgomery Incised* (Adena)
3. check stamped—*Wright Check Stamped* (Woodland)
4. fabric impressed—*Baumer Fabric Impressed* (Woodland)
5. simple stamped—*Rough River Simple Stamped* (Woodland)

H. Unaltered surface, limestone temper
1. interior smoothed, tool marks frequently visible, average less than 10 mm. thick
a. northern and central distribution—*Adena Plain* (Adena)
b. southern distribution—*Mulberry Creek Plain* (Woodland)
2. interior not smooth, average more than 10 mm. thick—*Fayette Thick* (Adena)
3. interior not smooth, average less than 10 mm. thick—*Rough River Plain* (Woodland)

I. Cordmarked, limestone tempered
1. cordmarking random
a. thick, over 10 mm.—*Fayette Thick* (Adena)
b. thin, under 10 mm.—*Rough River Cordmarked* (may be same as Flint River Cordmarked) (Woodland)
2. cord wrapped dowel impressed—*Baumer Fabric Impressed* (Woodland)
3. individual cord impressed in rectilnear designs—*Baumer Cordmarked* (Woodland)

J. Shell tempered
1. surface not altered—K
2. surface altered—N

K. Shell tempered, surface unaltered
1. thick over 10 mm.—L
2. thin, under 10 MM.—M

L. Shell tempered, unaltered surface, thick
1. (coarse shell temper) tool marks on the interior—*Wickliffe Plain* (Mississippian)

2. (coarse shell) no tool marks on interior
   a. northern distribution—*Fox Farm Salt Pan* (Fort Ancient)
   b. southwestern distribution—*Kimmswick Plain* (Mississippian)

M. Shell tempered, surface unaltered, thin
1. rough surface, heavy temper—*Neeley's Ferry Plain* (Mississippian)
2. medium rough surface, medium temper—*Madisonville Plain* (Fort Ancient)
3. smooth surface
   a. frequently polished, sometimes black—*Bell Plain* (Mississippian)
   b. not polished—*Fox Farm Bowl* (Fort Ancient)

N. Shell tempered, surface altered
1. incised or engraved—O
2. cordmarked—P
3. negative painted—*Angel Negative Painted* (Mississippian)
4. net impressed
   a. northern distribution—*Madisonville Net-Impressed* (Fort Ancient)
   b. southwestern distribution—*Kincaid Net-Impressed* (Mississippian)
5. punctated on rim—*Manly Punctated* (Mississippian)
6. perforated—*Fox Farm Colander* (Fort Ancient)
7. check stamped—*Fox Farm Check Stamped* (Fort Ancient)
8. groove-paddle decoration—*Madisonville Grooved Paddled* (Fort Ancient)
9. fabric impressed
   a. on exterior
      1. coarse shell—*Kimmswick Fabric Impressed* (Mississippian)
      2. fine shell—*Fox Farm Salt Pan* (Fort Ancient)
   b. on interior—*Tolu Interior Fabric Impressed* (Mississisppian)
10. red paint on one surface—*Old Town Red* (Mississippian)
11. parallel groove paddle impressions—*Madisonville Grooved Paddled* (Fort Ancient)

O. Shell tempered, incised or engraved
1. thick incision—*Wickliffe Incised* (Mississippian)
2. polished, with parallel horizontal incised lines on rim—*Mound Place Incised* (Mississippian)
3. overlapping incisions in diamond shape—*Beckwith Incised* (Mississippian)
4. engraved line filled triangular designs—*O'Byam Engraved* (Mississippian)
5. incised line filled triangular designs—*O'Byam Incised* (Mississippian)
6. incised curvilinear gillouche on rim—*Matthews Incised* (Mississippian)
7. incised lines diagonal to rim with outlining lines—*Feurt Incised* (Fort Ancient)
8. incised spiraling swastikas—*Rhodes Incised* (Mississippian)
9. engraved bands of cross-hatching—*Walls Engraved* (Mississippian)

P. Shell tempered, cordmarked
1. northern distribution
   a. cordmarkings clear—*Madisonville Cordmarked* (Fort Ancient)
   b. cordmarkings not clear, some smoothing—*Fox Farm Cordmarked* (Fort Ancient)
2. southern distribution—*McKee Island Cordmarked* (Mississippian)

Accepted for publication 23 October 1961.

ACADEMY AFFAIRS

1961 Fall Meeting

The forty-seventh annual meeting of the Kentucky Academy of Science was held on the campus of the University of Kentucky on October 21, 1961.

The first item of business was a report from the President outlining his activities and those of the Academy during the past year. A copy of the report is appended hereto. W. Jillson moved that the report be accepted. The motion was seconded and carried.

The minutes of the previous meeting were read and approved.

The treasurer's report, previously audited by R. Boyer, C. Isbell, and C. Henrickson, was read by R. Chapman. It was moved and seconded that the report be accepted. The motion carried.

M. Wharton reported on the AAAS meeting and emphasized the interest of AAAS in the histories of the various state academies of science. She pointed out that 22 of the 50 states have completed their studies and that Kentucky is one of 16 states that has done nothing. R. Barbour pointed out that in 1963 the Academy will be 50 years old and he suggeested that an issue of the Transactions might well be devoted to the history of science in the state and a history of the Academy. W. Jillson felt this to be an excellent idea. He pointed out that he edited and financed the Transactions from 1914-1924. He then moved that the chairman select a committee to convey to the executive committee the discussion regarding the 50th anniversary and have them suggest an appropriate course of action. The motion was seconded and carried.

R. Weaver pointed out that many academies have a History of Science section and that they feel a study of history to be a function of the Academy.

M. Christopher reported on the activities of the Junior Academy of Science. The Junior Academy held a meeting in Louisville during the fall of 1960. No spring meeting was held and no fair was held because of a conflict of dates for use of the fairgrounds. The Junior Academy grew, especially in Western Kentucky, in spite of a definite lack of activity. He pointed out that the Academy constitution calls for three directors and suggested that the Academy appoint two others. The several people suggested as possible help for him during the 1960-1961 year were not able to give him any assistance.

G. Levey reported for the executive committee. Only one item of discussion at the executive committee was brought to the attention of the Academy. The president's report included an item with regard to encouraging scientific research in the state. The committee felt that the Academy might recommend to College presidents that substantial reductions of teaching loads should be made for those faculty qualified and interested in doing research. W. Jillson moved that the Academy approve the recommendation from the executive committee. R. Barbour amended the statement to read—who have demonstrated an ability for and show an interest—. The amended motion carried.

L. Dawson reported for the research grant committee (L. Dawson, C. Whittle, M. Wharton) that one proposal had been received and recommended that the $100 grant be given. Dr. T. Kargl of Ursuline College received the grant for an extension of his study of carotenoids.

A list of new members was read for approval by the Academy. The names read were Woodrow W. Barber, Robert Bivins, Edward T. Browne, James R. Chaplin, Barbara Conkin, James Conkin, Evelyn Cole, Anne Cunningham, Mary Ellen Curtin, Tyrus Davis, James E. Douglass, A. E. Elkayar, Louis Eyermam, Wallace W. Hagan, Raymond Hampton, Rosemary Hartman, Alton Harvill, Jr., Howard Hopkins, Thomas A. Hutto, Charles Isbill, Arthur L. Jackson, Sanford

Jones, Thomas Kargl, Roger Katz, William Leach, Roy C. Lester, Preston McGrain, Zona B. McGuirt, John C. Philley, Dan Pittillo, William T. Query, Thomas G. Roberts, Carolyn Schottland, Herbert E. Shadowen, Claude Wade, and Mrs. Harriet Williams. W. Jillson moved that they be accepted. The motion was seconded and carried.

H. H. LaFuze asked about the status of the Thomas Hunt Morgan room. M. Wharton pointed out that the Academy agreed to furnish a room several years ago and that money is needed before more can be done. W. Jillson felt that a room on the U. K. campus honoring him might be more meaningful and to the point rather than in the Morgan house where he would be overpowered by the large number of rooms for other dignitaries. H. Hancock moved that the Academy contribute $50 toward furnishing the room. Some discussion followed in which it was pointed out that Thomas Hunt Morgan is Kentucky's only Nobel prize winner. The motion was seconded and carried.

R. Barbour suggested that the new president and executive committee might consider the establishment of a Thomas Hunt Morgan scholarship of some kind.

The question was raised about the possibility of having an open section of the Academy for papers not logically falling under any of the present section headings. The answer given was that any section could be started that had enough interest to have a program.

The nominating committee (P. Panzera, W. Owsley, W. Clay) reported the following nominees:

President Elect: L. Dawson
Vice-President: J. Conkin
Secretary: G. Levey
Treasurer: P. Ray
AAAS Rep.: M. Wharton
Board of Directors: W. Read, R. Wiley

The report was accepted and the nominees elected unanimously.

C. Whittle moved that there be recorded in the minutes the Academy's appreciation to R. Chapman for his eight years of service as treasurer of the Academy. The motion was seconded and carried.

H. H. LaFuze then gave the gavel to C. Whittle. C. Whittle appointed M. Christopher and T. Hutto as Junior councillors and promised to appoint an additional. He appointed H. LaFuze and C. Jackson to be in charge of the Science Talent search. He appointed M. Wharton, R. Barbour, and W. Jillson to begin work on the study of the history of the Academy and of science in Kentucky.

An invitation to meet at Western Kentucky State College in the fall of 1962 was issued. An invitation was issued by M. Wharton for the 1962 spring meeting. These were left for consideration by the executive committee.

The meeting adjourned at 2:45 p.m.

Approximately 90 members and guests attended the annual dinner, where Dr. Richard P. Goldthwait gave an illustrated lecture "Underneath Antarctic Ice."

Report of the Treasurer for the Year 1960-61

Balance in checking account on October 1, 1961		$ 590.22
Income October 1, 1960-October 1, 1961		
Regular membership dues	$ 945.00	
Sustaining membership dues	230.00	
Industrial membership dues	500.00	
A.A.A.S. research grant	120.00	
Subscriptions, Transactions of the K.A.S.	34.00	
Sale of reprints	152.69	
University of Louisville, 200 copies Transactions	200.00	
Sale of advertising	100.00	
Total income	$2,281.69	$2,871.91
Expenditures October 1, 1960-October 1, 1961		
Appropriation to Kentucky Research Foundation (Account # 2425) for publication of Volume 21 and Numbers 1 and 2 of Volume 22 of the Transactions of the Kentucky Academy of Science	$ 1,856.75	
Secretary's expenses, postage, printing, etc.	114.47	
Editor of Transactions expenses, postage, etc.	53.77	
Treasurer's expenses, postage, etc.	30.02	
Junior Academy expenses, councilor travel, etc.	25.46	
A.A.A.S. research grants	120.00	
Academy Conference dues	6.40	
	$2,206.87	$ 665.04
Balance in checking account on October 1, 1961		$ 665.04
Balance in account with Kentucky Research Foundation for publication of the Transactions of the K.A.S. 1959-1960 carryover		$ 200.00
1960-1961 excess		$ 193.78
Total		$ 393.78
Savings account		
Balance October 1, 1960		$ 605.32
Interest October 1, 1960-October 1, 1961		24.46
Balance October 1, 1961		$ 629.78

Respectfully submitted,
RICHARD A. CHAPMAN, Treasurer

Approved by:

C. Isbell

R. Boyer

C. Henrickson

Sectional Meetings

BACTERIOLOGY AND MEDICAL TECHNOLOGY SECTION

Genevieve Clark, Chairman
Margaret Hotchkiss, Secretary

The use of uricase in the assay of uric acid. Larry N. Bare* and R. F. Wiseman, Department of Microbiology, University of Kentucky, Lexington.

An inexpensive method of performing a test for 17 ketosteroids. Frank Adams* and I. F. Canner, Good Samaritan Hospital, Lexington.

Facts about blood banking. Gordon Bell, Central Baptist Hospital, Lexington.

Quality control in the laboratory, Denver Robertson, Medical Center, University of Kentucky, Lexington.

A comparison of erythrocyte counts by various methods (15 minutes). Ben Turpin, Lexington Clinic.

The isolation and enumeration of *Clostridium perfringens* from foods. Herbert E. Hall* and R. Angelotti, Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio.

Favus in Kentucky. A. B. Loveman and Emil Kotcher*, School of Medicine, University of Louisville.

ZOOLOGICAL SECTION

Robert Kuehne, Chairman
Dwight Lindsay, Secretary

Edney, J. M. and Huntsman, Harry. The Effects of Ultraviolet Radiation on *Schistosomation douthitti* Cercariae. Dept. of Zoology, University of Kentucky. (10 min.)

Sowards, Charles F. An Experimental Study of the Development of the Dorsal and Ventral Pancreatic Buds in the Chick Embryo. Dept. of Zoology, Univ. of Ky.

Reidlinger, C. R. The Influence the Differentiation of the Small Intestine of Chick Embryos Has on the Uptake of Ca-45 Sr89 and P-32. Biology Dept. Murray State College.

Davidson, Ursula. A Report on the University's Summer Institute for Science (and Mathematics) Teachers. Napier High School, Hazard, Ky.

Barbour, R. W. On the Behavior of *Plethodon glutinosus* as Influenced by Light. Zoology Dept. Univ. of Ky. (15 min.)

Lipscomb, William. Some Meteorological Factors Affecting the Activity of *Microtus*. Zoology Dept. Univ. of Ky. (15 min.)

Carpenter, J. M. Studies on Reproductive Potential in *Drosophila*. Zoology Dept. Univ. of Ky. (15 min.)

Lindsay, Dwight. A Report on the Developmental Biology Institute at Brevard College. Biology Department, Georgetown College.

BOTANY SECTION

Carl Henrickson, Chairman
Arland Hotchkiss, Secretary

Altered Metobolism of Carrot Slices Infected by *Thielaviopsis basicola*. Raymond E. Hampton, Department of Agronomy, University of Kentucky. 2" x 2" slides. 15 min.

Flora of Jefferson and Seven Adjacent Counties, Kentucky. Charles R. Gunn, Ross Seed Co. & University of Louisville. 15 min.

A Preliminary Report on the Flora of the Scottsburg Lowland: A Division of the Outer Bluegrass Province. Charles R. Gunn, Ross Seed Co. & University of Louisville. Slides. 15 min.

Seasonal Variations in the Populations of Certain Nematodes in Turf. Richard A. Chapman. Agronomy Department, University of Kentucky. 2" x 2" slides. 15 min.

Reports of Liliaceae New to Kentucky. Edward T. Browne, Jr. Department of Botany, University of Kentucky.

CHEMISTRY

Karl Hussung, Chairman
Arthur Fort, Secretary

"Some Aspects of the Use of Amides as Combined Dehydrating and Ammoniating Agents." Paul G. Sears. 20 mins.

"Studies on the Mills Reaction." Ellis V. Brown. 15 mins.

"Formation of Boronium Ions by the Reaction of Iodine with Amine Boranes." James E. Douglass. 15 mins.

BREAK—

"Precipitation of Lead Sulfate from Homogeneous Solution by Hydrolysis of Sulfamic Acid." Lora A. Shirley and William F. Wagner. 15 mins.

"The Effect of a Second Chelating Agent on the Distribution of Copper (II) Acetylacetonate Between Benzene and Water." Mary F. Richardson and William F. Wagner. 15 mins.

"Determination of Submicrogram Amounts of Tantalum and Iridium in Meteorites by Activation Analysis." Wm. D. Ehmann. 15 min.

PSYCHOLOGY

Ray H. Bixler, Chairman
Paul McNeeley, Secretary

Fulkerson, Samuel C., University of Louisville. "Behavioral Change and Prognosis."

Wilkie, Raymond A., University of Louisville. "The Analysis of Variance with Unequal and with Disproportional Subcell N'S."

Foulke, Emerson, University of Louisville. "Comprehension of Rapid Speech by the Blind."

Hahn, Hans, Transylvania College. "Report About New European Testing Approaches."

Jokl, Ernst, University of Kentucky. "The Psychology of Athletic Record Performances."

Donahoe, John, University of Kentucky: "Visual Exploration in the Hooded Rat."

Estes, Betsy W. and Griffith, Richard, University of Kentucky: "Tested Intelligence in Schizophrenics."

Vandenberg, Steven G., University of Louisville; Social Preception in Schizophrenics and Normal Adults and Children.

Cole, James, University of Kentucky: "A Multidimensional Analysis of the Picture Identification Test."

McNeeley, Paul, Asbury College. "Knowledge and Attitudes About Psychology as Recorded by Asbury College Freshmen, Fall Quarter, 1961."

GEOLOGY

James E. Conkin, Chairman
Marion D. Stallard, Secretary

Pleistocene Snails from Hickman, Kentucky. Ruth Browne, to be read by title, 1407 Elfin, Louisville, Ky.

Microfossils of the Pennsylvanian (Virgilian) Deer Creek formation of southern Kansas and northern Oklahoma. Barbara M. Conkin, 15 minutes; 35 mm slides, University of Louisville.

A new species of the bryozoan genus *Archimedes* from the Mississippian (Floyd Knob formation) of Kentucky. James E. Conkin, 15 minutes; 35 mm slides, University of Louisville.

Paleoecology of a Pleistocene deposit in the Louisville area. Donald McDonald to be read by title, University of Louisville.

New digitate sponge from the Middle Ordivician of Franklin County, Kentucky—by Dr. Willard R. Jillson. 15 Minutes

PHYSICS

Clifton A. Basye, President
Otis K. Wolfe, Jr., Secretary

The Physics My Grandfather Studied in 1849-50. P. C. Overstreet, Morehead State College.

Coulomb Distorted Stripping Amplitudes for Be9 (d,p) Be10 Reactions. Allison and Biggerstaff, University of Kentucky

Scintillation Response of Cesium Iodide (T1) to Heavy Particles. H. Scott, University of Kentucky

Comparison of Be9 (d,p) Be10 and Be9 (t,d) Be10 Reactions. J. A. Biggerstaff, R. S. Hood, and H. Scott, University of Kentucky.

Track Density Characteristics of Liquid Hydrogen Chambers. W. Sims, University of Kentucky

Solid Ionization Detectors for Charged Particle Spectroscopy. R. S. Hood, University of Kentucky

Calibration of a Plastic Scintillator for Counting 14.2 Mev Neutrons. F. Gabbard, University of Kentucky.

Panel Discussion of the Denver Conference on Undergraduate Curricula for Physics Majors.

Panel Members: C. A. Basye, Eastern Kentucky State College

D. M. Bennett, University of Louisville

F. D. Boercker, Western Kentucky State College

W. G. Read, Murray State College

INDEX TO VOLUME 22

INSTRUCTIONS FOR CONTRIBUTORS

The TRANSACTIONS OF THE KENTUCKY ACADEMY OF SCIENCE is a medium of publication for original investigations in science. Also as the official organ of the Kentucky Academy of Science, news and announcements of interest to the membership are published therein. These include programs of meetings, titles, abstracts of papers presented at meetings, and condensations of reports by the Academy's officers and committees.

Papers may be submitted at any time to the editor. Each manuscript will be reviewed by one or more editors before it is accepted for publication, and an attempt will be made to publish papers in the order of their acceptance. Papers are accepted for publication with the understanding that they are not to be submitted for original publication elsewhere, and that any additional printing shall be at a later date and shall be designated in an appropriate credit line as a reprint from the TRANSACTIONS OF THE KENTUCKY ACADEMY OF SCIENCE.

Manuscripts should be typed, double-spaced, with wide margins, on paper of good stock. The original and one carbon copy should be submitted, and the author should retain one additional carbon copy. It is desirable that the author have his colleagues read the manuscript for clarity of expression and typographical or other errors.

Titles must be clear and concise, and provide for precise cataloging. Textual material should be in clear, brief, condensed form. Footnotes should be avoided. Tables and illustrations are expensive and should be included only to give effective presentation of the data. Articles with an excessive number of tables or illustrations, or with poorly executed tables or illustrations, may be returned to the author for modification.

Line drawings and half-tones will appear as *text-figures*. Drafting should be carefully done (hand lettering generally is not satisfactory). Photographs should have good contrast and be printed on glossy paper. Text-figures are to be numbered consecutively and independently; on the back of each its number and the author's name should be written lightly in pencil. Each text-fiure must be referred to specifically in the text and must be provided also with a legend, the latter to be supplied as typed copy separate from the figures. Figures should be arranged into groups whenever possible and the legend for each group written as a separate paragraph. The amount of reduction desired should be indicated and should be consistent with the page dimensions of this journal. Indications of magnification should apply to the reduced figure.

The aim of the paper should be made clear in the introductory portion. If the paper is of more than a few pages it should contain a brief "Summary," which should be lucid without recourse to the rest of the article. In the interest of bibliographic uniformity, arrange all references under a "Literature Cited" heading, alphabetically by author and date, unnumbered, with textual citation by parenthetic insertion of author and date, as (Jones, 1940), or Jones (1940). Use initials for given names. Titles must be included. Abbreviate names of journals, using the form employed by Chemical Abstracts or Biological Abstracts. Separate the volume number from page numbers by a colon. References to books should include also the place of publication and the publisher.

The author is responsible for correcting the galley proof. Extensive alterations from the original are expensive and must be avoided or paid for by the author. Galley proofs must be returned promptly. Blanks for reprint orders will be supplied with the galley proof.